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For the
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The Journal *of* Orthopædic Surgery

REPORT ON 48 CASES OF TENDON TRANSPLANTATION OF THE FOOT. PHYSIOLOGICAL METHOD.

BY A. STEINDLER, M.D., F.A.C.S., IOWA CITY, IOWA.

Some time ago the author, in a paper in this Journal, on "Nutrition and Vitality of the Tendon in Tendon Transplantation," pointed to the advisability of preserving the physiological integrity of the tendon in surgical manipulation. This postulate for surgical procedure consists first in preserving or reconstructing the normal gliding apparatus of the tendon as advocated by Biesalski and Mayer.

To this was added the point of preserving the mesotenon of certain tendons for the sake of the nutrition of the tendon or, in other words, the avoidance of stripping procedures.

As to the necessity of reconstructing the gliding apparatus there exists now no diversity of opinion. As to the necessity of preserving the mesotenon of certain tendons the views may differ. It may be that some tendons will stand to a certain degree, to be stripped of mesotendoneal attachments. However, I have had occasion to observe, at secondary operation, evidence of degeneration following preceding stripping procedures. The strict observance of these physiological points may be considered by some to be too rigid a restriction in the application of tendon transference. But I believe in order to reclaim this method from the great discredit into which it has fallen, it was necessary to relegate it to its proper place and to eliminate a number of extensive tendon transplantations in many cases in which arthrodesis would be indicated instead of tendon transplantation.

Consequently, so far as the foot and ankle are concerned, the question resolves itself into three or four problems, owing to the fact that only a few tendons may be used for interexchange without violating the principles laid down in the above remarks.

The problems are as follows:

1. In paralysis of the tibialis anticus alone or along with slightly paralyzed extensors of the foot, the question of its substitution by the extensor of the big toe is to be considered. The fact that the latter muscle is so much weaker than the tibialis anticus should not absolutely militate against the exchange of these two tendons as long as the tibialis posticus is acting. In this report is included a number of cases of apparently isolated paralysis of the tibialis anticus, some with development of high arch and even contractures of the short flexors of the toes.

The technique of this operation has been described in a former publication.

2. Paralysis of the tibialis posticus. In paralysis of the tibialis posticus, substitution may be made by using the long common flexor of the toes which is located behind the sheath of the tibialis posticus. Both tendons can be embedded into a common sheath.

3. In paralytic pes calcaneus of moderate degree only, with paresis of gastrocnemius muscle, substitution can be made by using the tendon of the peronei. An incision, made midway between the outer edge of the tendo Achillis and posterior edge of the peronei, will give equal access to both sheaths, and side to side attachment of the tendon will be possible without interfering with broad mesotendoneum of the peronei.

4. Leo Mayer has described a technique for substitution of the paralyzed tibialis anticus by the peroneus longus. This latter tendon and muscle is isolated by long incision, liberated high up, inserted into the sheath of the tibialis anticus and fastened to the insertion of the scaphoid. This method was carried out in three cases.

5. In cases of paralysis of both tibialis anticus and tibialis posticus, a double transplantation was used combining the method of group 1 and 2; substitution of the tibialis anticus by the extensor of the big toe, of the tibialis posticus by the flexor of the big toe.

6. In cases of paralysis of either tibialis anticus or tibialis posticus combined with paresis of the gastrocnemius a double transplantation was done, combining method of group 1 or 2 with that of group 3, *i.e.*, substitution of the tibialis anticus by extensor hallucis or the tibialis posticus by the flexor digitorum and of the gastrocnemius by the peronei.

7. Finally, in cases of paralysis of both tibialis anticus and posticus and of the gastrocnemius, a triple transplantation was carried out, combining methods 1, 2, and 3; substitution of the tibialis anticus by the extensor of the big toe, of the tibialis posticus by the flexor of the toes and of the gastrocnemius by the peronei.

The main reason that tendon transplantation has fallen into disrepute is, in my opinion, aside from the disregard of certain physiological requirements, the fact that the indication of this method has been unduly extended to cases in which the existing indication was undoubtedly that of arthrodesis.

I submit in the following a report of 48 cases, in all of which the technique of tendon sheath preservation and preservation of the nutrition has been strictly observed, with the exception of the three cases of Mayer's method in which the peroneus tendon had to be severed from its mesotenon.

The operative results are graded as good, fair or poor. As a good result are regarded those cases in which there was not only distinct action of the implanted tendon in the direction of the paralyzed tendon, but where this action was also maintained during weight bearing and no disturbance of the balance existed.

As fair result are mentioned the cases in which there was only a slight muscle action, but no disturbance of balance on weight bearing.

All cases showing less result than this are classed as poor.

In determining definite results those cases are singled out in which one year or more has passed after operation in which weight bearing is allowed without any supporting contrivance, patient wearing an ordinary shoe.

GROUP 1. SINGLE TRANSPLANTATION. EXT. HALL. UPON TIB. ANT.

No.	NAME, AGE, DURATION	RESIDUAL PARALYTIC CONDITION. MUSCLES PARALYZED	OPERATION	OBSERV.	RESULT
1	H. S., 10 yrs. 6 yrs.	L. paralytic valgus. R. calcaneo-valgus	9-20-17 Ext. hall. to tib. ant. First oper. 9-9-15. Tendon transpl., old method, poor result.	1 yr.	Poor. Active extension but no supination. Paralysis too extensive. Should have had arthrodesis.
2	R. C., 8 yrs. 4 yrs.	L. paralytic valgus. R. total paral. Isolated paral. of tib. ant.	2-16-17 L. foot ext. hall. to tib. ant.	1 yr. 2 mos.	Good. Active supination. No. valgity on weight bearing. Wears ordinary shoe.
3	R. T., 16 yrs. 11 yrs.	R. paralytic club. L. paralytic valgus. L. isolated paral. tib. ant.	8-15-18 Ext. hall. to tib. ant. Lengthening tendo Ach.	6 mos.	Good. Good active supination. In cast.
4	W. M., 23 yrs. 14 yrs.	R. paralytic valgus. Paral. tib. ant. and post.	1-2-17 R. foot. ext. hall. to tib. ant. Lengthening tendo Ach.	2 yrs.	Good. Distinct supination. Wears ordinary shoe.
5	C. S., 10 yrs. 6 yrs.	L. paralytic valgus. Isolated paral. tib. ant.	2-13-17 Ext. hall to tib. ant. Tenotomy tendo Ach.	1 yr. 4 mos.	Good. Very good active supination. No valgus tendency when walking. Wears ordinary shoe.
6	R. S., 7 yrs. 7 yrs.	L. paralytic equino-valgus. Isolated paral. tib. ant.	4-5-17 L. foot ext. hall. to tib. ant. Lengthening tendo Ach.	1 yr. 3 mos.	Good. Very good active supination. No valgus tendency when walking. Wears ordinary shoe.
7	N. T., 12 yrs. 7 yrs.	L. paralytic equino-valgus. Isolated paral. tib. ant.	4-18-17 L. foot. Ext. hall. to tib. ant. Lengthening of tendo Ach.	1 yr. 1 mo.	Good. Active supination. No valgity when walking. Wears ordinary shoe.

8	D. C., 9 yrs. 8 yrs.	R. paralytic valgus. L. paralytic calcaneo-valgus L.foot paral. tib ant. and post.	5-22-17 R. foot. Ext. hall. to tib. ant. Lengthening of tendo Ach.	1 yr. 6 mos.	Good. Good active supination. No valgus tendency. Wears ordinary shoe.
9	R. M., 8 yrs. 3 yrs.	R. paralytic valgus. Paral. of tib. ant. and post.	6-12-17 R. foot. Ext. hall. to tib. ant.	1 yr. 9 mos.	Good. Good active supination. No valgity. Wears ordinary shoe.
10	C. L., 11 yrs. 6 yrs.	R. paralytic equino-valgus and cavus. Paral. tib ant. and post.	5-22-17 R. foot. Ext. hall. to tib. ant. Stripping os calcis.		Good. Active supination. No valgity. Did not report again.
11	H. H., 8 yrs. 6 yrs.	R. foot equino valgus and cavus. Isolated paral. tib. ant. with high arch.	5-25-17 Ext. hall. to tib. ant. Tenotomy tendo Ach.		Did not report back.
12	E. S., 11 yrs. 7 yrs.	R. foot paral. equino-valgus. L. paral. calcaneo-valgus. Isolated paral. tib. ant.	6-27-18 R. foot. Ext. hall. to tib. ant. Tenopl. tendo Ach. 7-9-17 L. Whitman.	7 mos.	Good. Active supination. No valgity. Wears ordinary shoe.
13	R. C., 9 yrs. 1 yr. 1 mo.	R. foot paral. valgus. Paral. tib. ant. and post.	8-6-18 Ext. hall. to tib. ant. Tenotomy tendo Ach.	6 mos.	Good. Active supination. No valgity. In cast.
14	R. G., 8 yrs. 6 yrs.	R. foot paral. Paral. tib. ant. gastrocn.	9-12-17 R. foot. Ext. hall. to tib. ant. Tenotomy tendo Ach.	1 yr. 4 mos.	Good. Active supination. No valgity. Wears brace.

No.	Name, Age, Duration	Residual Paralytic Condition. Muscles Paralyzed	Operation	Observ.	Result
15	K. G., 11 yrs. 8 yrs.	R. foot paral. valgus. L. calcaneo-valgus. Isolated paral. tib. ant.	12-6-18 R. foot. Ext. hall. to tib. ant. Tenotomy tendo Ach. 10-28-17 L. foot. Whitman.	1 mo. 1 yr. 1 mo.	Still in cast. Good.
16	A. H., 14 yrs. 7 yrs.	L. foot paral. valgus. Isolated paral. tib. ant.	3-28-18 L. foot. Ext. hall. to tib. ant. Tenotomy tendo Ach.	6 mos.	Good. Active supination. No valgity. In cast.
17	M. S., 12 yrs. 7 yrs.	L. paralytic equino-valgus. Partial paral. tib. ant..	5-17-18 Ext. hall. to tib. ant. Tenotomy tendo Ach.	8 mos.	Good. Active supination. No valgity. Wears ordinary shoe.
18	M. S., 12 yrs. 9 yrs.	R. paralytic equino-valgus. Isolated paral. tib. ant.	5-4-18 Ext. hall. to tib. ant. Tenotomy tendo Ach.	8½ mos.	Good. Active supination. No valgity. Wears brace.
19	L. C., 8 yrs. 2½ yrs.	R. paralytic valgus. Isolated paral. tib. ant.	5-23-18 R. foot. Ext. hall. to tib. ant.	6 mos.	Good. Active supination. No valgity. Still in cast.
20	C. D., 9 yrs. 7 yrs.	R. paralytic equino-valgus. Isolated paral. tib. ant.	6-22-18 R. foot. Ext. hall. upon tib. ant.	6 mos.	Good. Active supination. No valgity. Wears brace.
21	D. F., 10 yrs. 8 yrs.	R. paralytic valgus.	7-2-18 Ext. hall. to tib. ant.	6 mos.	Good. Active supination. No valgity. Still in cast.
22	L. R., 10 yrs. 7 yrs.	R. paralytic valgus. Paral. tib ant. and post.	9-12-17 Ext. hall. to tib. ant.	1 yr. 4 mos.	Very good. Active supination. No valgity. Wears ordinary shoe.

GROUP 2. SINGLE TRANSPLANTATION. FL. DIG. TO TIB. POST.

No.	Duration Name, Age.	Residual Paralytic Condition. Muscles Paralyzed	Operation	Observ.	Result
1	N. S., 13 yrs. 12 yrs.	R. paralytic valgus. L. paralytic contr. Paral. tib ant. and post.	1-8-18 R. fl. dig. to tib. post.	10 mos.	Poor. Insufficient substitution. In cast.
2	D. D., 6 yrs. 4 yrs.	R. paralytic valgus. Paral. tib. post.	12-4-18 R. foot. Fl. dig. to tib. post.	1 yr. 2 mos.	Good. Active supination of tib. post. No valgity. Wears ordinary shoe.

GROUP 3. SINGLE TRANSPLANTATION. PERONEI TO TENDO-ACHILLIS.

No.	Duration Name, Age.	Residual Paralytic Condition. Muscles Paralyzed	Operation	Observ.	Result
1	K. H., 6 yrs. 6 yrs.	R. paralytic calcaneus. Paralyzed gastrocn.	5-29-17 R. foot. Peronei to tendo Ach. Tenotomy of tendo Ach.	1 yr. 3 mos.	Good. Good action of tendo Achillis. Wears ordinary shoe.
2	J. Q., 4 yrs. 3 yrs.	R. paralytic calcaneus.	6-16-18 Peronei to tendo Ach.	7 mos.	Good action, Tendo Achillis. In cast.
3	R. P., 4 yrs. 4 yrs.	Spastic equinus-valgi, congenital.	1-16-19 Both feet. Peronei to tendo Ach.		Too recent. In cast.
4	A. S., 7 yrs.	R. paralytic calcaneus.	3-8-17 R. foot. Peronei to tendo Ach.	1 yr. 8 mos.	Good. Good action of tendo Achillis. Wears ordinary shoe.
5	W. H., 10 yrs. 10 yrs.	Spastic equino-valgi.	10-18-17 L. foot. Peronei to tendo Ach.	1 yr.	Good. No calcaneus tendency of foot. In braces.

GROUP 4. SINGLE TRANSPLANTATION. PERONEUS LONGUS TO TIB. ANT. MAYER'S METHOD.

No.	Duration Name, Age,	Residual Paralytic Condition. Muscles Paralyzed	Operation	Observ.	Result
1	M. H., 6 yrs. 6 yrs.	R. paralytic equino-valgus. Paralysis tib. ant. and post.	8-5-18 R. foot. Peroneus long. to tib. ant.	2 mos.	Good. Too recent. Still in cast.
2	A. M., 12 yrs. 6 yrs.	L. paralytic calcaneo-valgus Paral. tib. ant and post. Partial paral. gastrocn.	10-3-18 L. foot. Peroneus long. to tib. ant. Peroneus brevis to tendo Ach.	3 mos.	Good. Active supination. Active plantar flexion.
3	B. R., 14 yrs. 9 yrs.	R. paralytic valgus. Paral. shoulder, elbow and hand. Paral. tib. ant. and post.	8-13-18 R. foot. Peroneus long. to tib. ant.	5 mos.	Good. Active supination.

GROUP 5. DOUBLE TRANSPLANTATION. EXT. HALL. TO TIB. ANT.; FLEXOR DIGIT. TO TIB. POST.

No.	Duration Name, Age,	Residual Paralytic Condition. Muscles Paralyzed	Operation	Observ.	Result
1	M. O., 10 yrs. 8 yrs.	R. paralytic valgus. Paral. tib. ant. and post.	5-15-17 Ext. hall. to tib. ant. 2-21-18 Fl. dig. to tib. post.	1 yr. 8 mos. 11 mos.	Good. Active supination. No valgity. Result improved by second transplantation. Wears ordinary shoe.
2	E. H., 5 yrs. 2 yrs.	R. paralytic valgus. Paral. tib. ant. and post.	8-15-18 Ext. hall. to tib. ant. Fl. dig. to tib. post.	6 mos.	Fair. Action of tib. ant. good. Action of tib. post. poor. In cast.
3	L. R., 10 yrs. 7 yrs.	R. paralytic valgus (moderate). L. paralytic valgus (pronounced).	8-22-18 Fl. dig. to tib. post. L.	5 mos.	Good. Still in cast.
4	B. H., 11 yrs. 2 yrs.	L. paralytic valgus. Paral. tib. ant. and post.	5-7-18 L. foot. Ext. hall. to tib. post.	8 mos.	Good. Active supination. No valgity. Wears brace.

5	L. O., 10 yrs. 7½ yrs.	R. paralytic calcaneo-valgus. L. paralytic valgus.	2-16-18 L. foot. Ext. hall. to tib. ant. Fl. dig. to tib. post.	1 yr.	Poor. Active supination slight. Valgity on weight bearing. Should have had arthrodesis.
6	V. S., 9 yrs. 5 yrs.	R. paralytic valgus. L. paralytic valgus.	5-21-17 Transpl. r. foot. 7-5-18 Ext. hall. to tib. ant. Fl. dig. to tib. post.	1½ yrs.	Poor. Active supination but valgity on weight bearing. In braces. Whitman operation should have been performed.
7	G. S., 16 yrs. 14 yrs.	R. paralytic valgus. L. paralytic equinus.	9-9-17 Transpl. r. foot. 8-1-18 Ext. hall. to tib. ant. Fl. dig. to tib. post.	1 yr. 4 mos.	Poor. Action of tib. ant. but no active supination. Valgity on weight bearing. Indication arthrodesis.

GROUP 6. DOUBLE TRANSPLANTATION. PERONEI TO TENDO-ACHILLIS; EXT. HALL. TO TIB. ANT. OR FL. DIG. TO TIB. POST.

No.	NAME, AGE, DURATION	MUSCLES PARALYZED RESIDUAL PARALYTIC CONDITION.	OPERATION	OBSERV.	RESULT
1	P. M., 8 yrs. 6½ yrs.	R. paralytic calcaneo-valgus. Paral. tib. ant. and post.	5-2-17 Right. foot tendon transpl. 8-2-17 Peronei to tendo Ach. Ext. hall. to tib. ant.	1 yr. 5 mos.	Good. Good active supination. No valgity. Wears ordinary shoe.
2	W. H., 8 yrs. 6½ yrs.	R. paralytic calcaneo-valgus. Paral. of tib. ant., tib. post., tendo-Achillis.	10-25-17 Ext. hall. to tib. ant. Peronei to tendo Ach.	1 yr. 3 mos.	Good. In cast.
3	G. L., 12 yrs. 7 yrs.	L. paralytic calcaneo-valgus. Paral. of tib. ant., tib. post., tendo-Achillis.	6-28-17 L. foot. Ext. hall. to tib. ant. Peronei to tendo Ach.	1 yr. 6 mos.	Poor. No supination.

No.	Name, Age, Duration	Residual Paralytic Condition. Muscles Paralyzed	Operation	Observ.	Result
4	W. A., 8 yrs. 6 yrs.	L. paralytic calcaneo-valgus. Paral. tib. ant., tib. post., gastrocn.	5-29-17 6-30-17 Ext. hall. to tib. ant. Peronei to tendo Ach.	1 yr. 7 mos.	Fair. No valgity. Slight power of supination. Still in cast.
5	R. D., 6 yrs. 4½ yrs.	R. paralytic calcaneo-valgus. Paral. tib. ant., tib. post., gastrocn.	7-5-17 Ext. hall. to tib. ant. Peronei to tendo Ach.	4 mos.	Good. Did not report again.
6	W. S., 11 yrs. 9 yrs.	L. paralytic calcaneo-valgus. Paral. tib. post., gastrocn.	11-13-17 Fl. dig. to tib. post. Peronei to tendo Ach.	4 mos.	Good. Did not report later.

Group 7. Triple Transplantation. Ext. Hall. to Tib. Ant.; Fl. Dig. to Tib. Post.; Peronei to Tendo-Achillis.

No.	Name, Age, Duration	Residual Paralytic Condition. Muscles Paralyzed	Operation	Observ.	Result
1	D. C., 11 yrs. 7½ yrs.	R. calcaneo-valgus. Paral. tib. ant., tib. post., gastrocn.	6-6-17 Ext. hall. to tib. ant. 8-18-18 Fl. dig. to tib. post. Peronei to tendo Ach.	1 yr. 5 mos.	Good. Wears brace.
2	S. D., 7 yrs. 5 yrs.	L. calcaneo-valgus. Paral. tib. ant., tib. post., gastrocn.	4-2-18 Ext. hall. to tib. ant. Fl. dig. to tib. post. Peronei to tendo Ach.	9 mos.	Good. In cast.
3	L. G., 11 yrs. 8 yrs.	L. calcaneo-valgus. Paral. tib. ant., tib. post., gastrocn.	10-20-17 5-23-18 Ext. hall. to tib. ant. Fl. dig. to tib. post. Peronei to tendo Ach.	1 yr. 8 mos.	Fair. In cast.

	Total	Total Results			Not Determined
		Good	Fair	Poor	
Group 1	22	20	0	1	1
Group 2	2	1	0	1	0
Group 3	5	4	0	0	1
Group 4	3	2	0	0	1
Group 5	7	3	1	3	0
Group 6	6	4	1	1	0
Group 7	3	2	1	0	0
Total	48	36	3	6	3

Of this group of 48 cases, 36 showed good result, or 75%. The rest are divided into fair, poor, and undetermined on account of too recent operation.

Result in Cases Observed One Year or More.

	Total	Result			
		Good		Fair	Poor
		Wearing Shoe	Wearing Cast or Brace		
Group 1	10	8	1	0	1
Group 2	1	1	0	0	0
Group 3	3	2	1	0	0
Group 4	0	0	0	0	0
Group 5	4	1	0	0	3
Group 6	4	1	1	1	1
Group 7	2	0	1	1	0
Total	24	13	4	2	5

By eliminating all cases in which less than one year had elapsed bebetween operation and time of writing, there remain 24 cases which have been observed one year after operation. Of these, 17 cases, or 70%, showed good result. By again eliminating all cases which are still in some kind of supporting contrivance, as cast or brace, we have at present 13 cases, or 57%, which have definitely shown good operative results. Of the four remaining in cast it is to be expected that their present good result will be added to this number, making a definite percentage of good result, reaching the neighborhood of 70% for all cases.

IMPAIRMENT OF FUNCTION OF THE HAND DUE TO WAR INJURIES.

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Our subject includes impairment due to lesions of the peripheral nerves in the arm and forearm and that due to so-called functional causes, as well as impairment which follows local injuries of the hand itself, with destruction of bones, joints and tendons. I shall give little thought to wound healing, but consider, rather, diagnosis and proper mechanical treatment: early treatment which prevents deformity, and after-treatment which leads to satisfactory function. In many war injuries, including those involving the hand, skillful early treat-

ment minimizes,—aborts even,—subsequent deformities which impair function. My cases number about one hundred.

I. RECENT WOUNDS OF THE HAND.

a. Joints Not Involved. If a wound is recent, but does not involve a joint, if there is no reason to expect permanent joint stiffness, if there is no joint inflammation,—then I encourage active movement from the start, in elbow, wrist, and hand, and daily move all these joints, once at least, through their complete range of motion. Thus one prevents stiffness and avoids the necessity of manipulating later under an anaesthetic. In that it maintains nutrition, a useful adjunct is massage. In uninjured areas it is indicated, of course, at any time. During convalescence, in an injured area, deep massage promotes circulation in newly formed masses of cicatricial tissue. In this connection, active manual work in a curative workshop should not be forgotten.

b. Joints Involved. If one excludes nerve and so-called functional lesions, impairment of function in the hand is due usually to stiffened, ill-positioned joints. If a joint itself has recently been wounded, if neighboring tendons or other tissues in its vicinity are destroyed, as an aftermath of the dense scar that is sure to form, one may hope for nothing better than a stiff joint; and in this event it is essential that the joint become fixed in its position of greatest utility.

This axiom suggests at once the importance of proper splinting. Not every hand injury requires the application of a splint. But if a splint be necessary, it is obvious that its use should be continued until danger of deformity has been eliminated; it is obvious that it should not be applied too tightly, for this ill-omened procedure may lead to ischaemic paralysis (Fig. 1). These two rules are usually observed; it is not un-

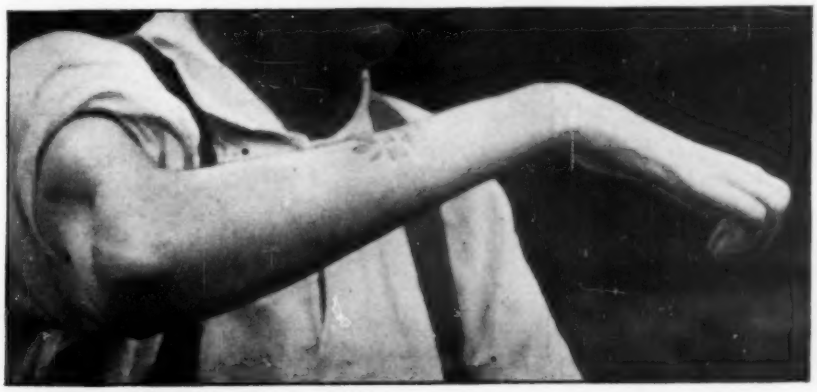

FIG. 1.—Ischaemic paralysis from bad splinting. No nerve lesion.

common, however, for splints to be applied in an improper position.

To use the hand with facility, a patient must be able: 1, To supinate the palm at least half-way; 2, to dorsiflex the wrist-joint; 3, to bend the metacarpo-phalangeal joints nearly, if not quite, to a right angle.

If, then, one expects, as an end result, permanent loss of supination and of pronation, let the forearm be fixed,—let the hand be in a position,—approximately midway between these two, erring slightly on the side of supination. Secondly, let all injuries in the neighborhood of the wrist-joint be fixed with the wrist dorsi-flexed. A straight splint or no splint at all permits palmar flexion; and with palmar flexion one gets improper balance between the strong flexors of the fingers and the relatively weak extensors, resulting in incomplete closure of the fingers and a powerless hand-grasp. A splint which dorsiflexes the wrist should lie on the ventral, rather than on the dorsal, aspect of the forearm. For the reason that the Jones short cock-up splint prevents flexion at the metacarpo-phalangeal joints, it is an imperfect splint. A proper cock-up has so little bearing surface in the palm of the hand that it permits flexion at these joints and does not modify the contour of the palmar arch; it extends well up the forearm. Very satisfactory cock-ups may be made from plaster of Paris (Fig. 2). Finally, if one expects permanent anchylosis of a metacarpo-phalangeal joint, let such a joint be fixed in semi-flexion.

FIG. 2.—Short cock-up splint. Plaster of Paris. Metacarpo-phalangeal joints have free movement.

These positions of choice are not demanded immediately after injury. Indeed, for the first few days, the injured region should be placed in a position of rest. Rough handling should be scrupulously avoided. But, shortly, account must be taken of the position necessary for a good functional result. Deformity accruing from contracting scar tissue, be it deep or superficial, must be modified,—must be counteracted,—by resistance, either continuous or intermittent (Fig 3).

FIG. 3.—Superficial wound, flexor surface of wrist. Contracture. Improper splinting.

II. OLD WOUNDS OF THE HAND.

a. Joints Not Involved. We have considered so far patients with recent wounds,—first, those with wounds which do not involve a joint, and secondly, those with wounds involving a joint. Consider, now, a large group of patients with old wounds which do not involve a joint, but in whom the joints of the hand have been allowed to become stiff in an improper position: joints which still retain much of their former integrity and which are controlled by muscles and tendons that still functionate. Their customary method of attempting to mobilize such joints by vigorous manipulation under an anaesthetic is futile, unless a patient can be induced to continue active movement immediately after manipulation. Too often a patient is unwilling to do this because of pain, for, by manipulation, a quiescent joint has, perhaps, been converted into an acutely inflamed one. More, then, may ordinarily be accomplished by gradual mobilization. In the case of the hand it is my custom to observe the following procedure:

1. If the fingers are fixed in flexion. Place the wrist in a position of palmar flexion and maintain this position by counter-pressure on

the dorsum of hand. Procure, first, extension of the interphalangeal joints; next, of the metacarpo-phalangeal joints; and, finally, dorsiflexion of the wrist-joint.

2. If the fingers are fixed in extension. Place the wrist in dorsiflexion and maintain this position by counterpressure in the palm of the hand. Procure, first, flexion of the metacarpo-phalangeal joints; next, of the interphalangeal joints.

Realization is often a very difficult matter, but if freedom of motion is to be had at all, it is had fairly quickly. There are sundry devices for procuring gradual mobilization. The violin splint, first described, I believe, by Osgood, is serviceable for either type of case, but has to be adjusted carefully and frequently. Another good one, particularly for cases of the second group, is the simple plaster splint devised by Langworthy. To make this splint, for a case of the second group, form a plaster-of-Paris gutter over the extensor surfaces of forearm, hand and fingers. On the upper surface of the gutter place a layer of stout cloth. And on the upper surface of the cloth a second layer of plaster-of-Paris bandages. Bind the edge. Dry thoroughly. Score each plaster layer cross-wise at a level of the several joints, leaving untouched the layer of cloth, which serves, in each instance, as a hinge. Day by day, increasing flexion may be secured in the metacarpo-phalangeal and in the interphalangeal joints, by flexing the hinged distal portion of the splint. Flexion thus gained is maintained by adhesive strips running over the end of the splint. The proximal end of the splint is anchored to the forearm by a wide adhesive plaster band.

The idea is more important than a particular device; whichever is used, one must bear in mind, primarily, the three cardinal requisites for good hand motion,—namely, ability to semi-supinate, to dorsiflex the wrist, and to flex the metacarpo-phalangeal joints; and, in the second place, the need of removing apparatus daily, in order to move each joint through its full permitted range of motion.

If a wound is not in proximity to a joint, but has destroyed a tendon, one may sometimes have recourse to tendon transplantation. Suppose, for example, a wound over the third metacarpal bone which has invalidated the extensor to this finger,—and, ordinarily, the extensors rather than the flexors are invalidated. In such an exigency one may transplant the proximal end of the tendon of the extensor indicis into the distal end of the extensor of the third digit. Such a transplantation is obvious, and, although the field is limited, other similar opportunities now and again arise. But it should be borne constantly in mind that tissues in the region of transplantation must be fresh. It

is impossible to transplant successfully in an area already impaired by scar.

Gradual mobilization is pertinent in instances of Volkmann's contracture which occasionally follow war injuries, due either to tight bandaging or to pressure within the arm. In this, the contracture is caused by partial coagulation of the proteids of the muscles which terminates in a fibrous myositis. To cure the condition, operative procedures are ineffective. Far better results are obtained by fixing in proper position, successively, the several groups of joints.

1. With the wrist in flexion, the fingers may be straightened and splinted, with finger-splints or plaster finger-cots.

2. A few days (three or four) later, with the wrist still in flexion, the metacarpo-phalangeal joints are stretched, and the splinted fingers and palm are placed on a flat splint.

3. After another lapse of a few days, the wrist may gradually be dorsiflexed.

The degree of recovery depends, of course, on the amount of muscle destruction and the age of the patient. In some instances in children recovery has been complete.

b. Joints involved. Let us take up now a fourth group of hand lesions: joints that are stiff in an improper position, joints which retain little or none of their former integrity, bordered by scar tissue and partly destroyed tendons. In the hand, it is obvious that a missile which destroys a joint must usually destroy adjacent soft tissues, including tendons. It is true, also, that in war injuries one sees, oftener than in civil practice, a synovitis spreading along tendon sheaths from the injured area. One is tempted, at first, to putter with lesions of this sort; to try to restore function by:

1. Passive manipulation under an anaesthetic, designed to loosen joints and to free tendons.

2. Gradual stretching of the kind advocated in a preceding paragraph.

3. Resection of a joint, in the hope of forming a mobile articulation.

4. Dissection of tendons from scar tissue, with suture of the tendon ends, if they be cut.

5. Formation of tendon sheaths from fascia lata, Cargile membrane or other extraneous tissue.

These procedures have a very, very limited field of usefulness. A joint which has been invaded by a missile, which has been allowed to

drain and has become stiff, will never become freely movable under manipulation; nor will this manoeuvre ever free, permanently, tendon buried in scar tissue. The manufacture of new joints under the given premises, I regard as an almost hopeless task. No attempt to repair or to free tendons in an area of scar tissue, has, to my knowledge, been successful. And to provide new tendon sheaths from a foreign tissue, in the expectation of getting a smooth runway, is to court failure. I have never utilized fat tissue for this purpose and it is fair to say that recent reports would lead one to believe that a properly functioning tendon sheath may be made from fat tissue.

Now for constructive facts. By manipulation or by open operation the wrist-joint may be placed in a cock-up position and permitted to anchylose, for we must never forget that this is the position of choice. For wounded, stiffened joints of the digits or of the metacarpo-phalangeal range I know of no satisfactory treatment. We must usually admit defeat by resorting to amputation. A stiff, extended finger is a nuisance. Not only is it in the way, but, if it be one of the last three digits, one finds that the lateral vincula,—the accessory slips,—of the extensor communis digitorum make an admirable check-rein on flexion of the remaining intact digits.

If adjoining fingers are intact, it is not always a wise policy to save as much of a finger as possible, even in cases where the stump is freely movable. A movable stump is useless unless it has gripping power; a third of a finger is often worse than none at all. Certainly if the stump is immobile, it is well to amputate just behind the metacarpal head. If two or more fingers are to be amputated, the metacarpal bones must be removed more liberally, in order to bring the remaining digits into closer approximation. The thumb is the most valuable digit, the index finger next. With these two alone, in good working order, a patient may accomplish much; and the loss of one or two fingers, of itself, incapacitates a hand little, provided that the thumb may be brought into apposition with the other digits.

To these somewhat radical suggestions one must make this exception. If a hand is badly shattered, but still retains mobility in one or another joint, it is sometimes advisable to save as much as possible from the wreckage,—to procure, perhaps, a mobile thumb and an index finger stiffened in semiflexion. Otherwise, our only alternative may well be amputation of the hand. And while this war has brought forth a few satisfactory and inexpensive substitutes for a man's hand, they are designed particularly for the laboring man. I know of only one that is aesthetic and delicate and that one is expensive (Fig. 4).

FIG. 4.—Extensive involvement of extensor tendons. Amputation of the two middle fingers indicated.

We all know that many war wounds may be successfully closed by delayed primary or by secondary suture,—yes, even by primary suture, —that, in clean cases, tendons may be sutured initially, that nerves may be so repaired. If, to the contrary, a wound is drained, it is essential to delay reconstructive operations for several months, for fear of "latent sepsis." With injuries to soft tissues alone, three months should elapse after a wound has healed; with injuries to bone, at least six months. I have seen "latent sepsis" burst into a most active sepsis eight months after the healing of a compound fracture of the radius. And at the time of a reconstructive operation fifteen hundred units of antitetanic serum are to be given. At this operation, too, one must be careful to dissect out old scar tissue, with its imbedded nerve filaments. Painful scars are all too common. In amputating, surgeons often forget that nerves should be pulled on a stretch and cut short.

III. IMPAIRMENT DUE TO PERIPHERAL NERVE LESIONS.

Here we have a very different type of case: that in which there is impairment due to injury of the peripheral nerves supplying the hand. The peripheral nerves with which we are concerned are three: the median, ulnar, and musculo-spiral.

a. Diagnosis of Median, Ulnar, and Musculo-spiral Lesions. The diagnosis of a particular lesion, the determination of prognosis and of treatment,—these are usually dependent on the observation of:

1. Motor response to faradic (and galvanic) current in specific muscles.
2. Active muscular response on the part of the patient.

3. Deformity and atrophy.
4. Vasomotor changes.
5. Sensory disturbances in the areas of distribution.

We are familiar with the fact that, in muscle tissue bereft of its nerve supply, reaction to degeneration begins in about a week or ten days after the nerve supply is cut off. For one experienced in electrotherapeutics it is therefore a simple matter to determine the scope of a nerve lesion affecting the hand, by stimulating the determining muscles over their motor points.

Oftentimes a correct diagnosis may be made without this refined procedure. The median nerve, for example, either directly or through its anterior interosseous branch, supplies all the muscles on the flexor surface of the forearm, except the flexor carpi ulnaris and the inner half of the flexor profundus digitorum. In the hand, the median supplies four and one-half muscles: the two outer lumbricals, the opponens pollicis, the abductor pollicis, and half of the flexor brevis pollicis. A patient, then, who has a complete median lesion cannot flex the terminal phalanx of his thumb (flexor longus pollicis); furthermore, with a complete lesion, on flexion of the wrist the hand is drawn to the ulnar side, because of paralysis of the flexor carpi radialis (Fig. 5). The forearm cannot be pronated beyond the midposition. There

FIG. 5.—Bullet wound, lower third right arm, on Sept. 8, 1916. Median nerve cut just below pronator radii teres. Sutured on April 23, 1917. Intense cyanosis. Note bending to ulnar side from overaction of flexor carpi ulnaris.

is atrophy of the ventral surface of the forearm and of the thenar eminence, without atrophy of the hypothenar. When at rest, the hand may show little or no deformity. If a median lesion is in the lower half of the forearm, a noticeable sign is inability to adduct the thumb and to rotate it inward (opponens pollicis).

The ulnar nerve, in the forearm, supplies the flexor carpi ulnaris

and the inner half of the flexor profundus digitorum. In addition, it supplies all the muscles of the hand except the four and one-half muscles just enumerated in the median group. A patient with ulnar paralysis cannot abduct and adduct his little finger. The hypothenar eminence and palm, as well as thenar eminence are much wasted. Owing to paralysis of the interossei, whose action is to flex the metacarpo-phalangeal joints and to extend the interphalangeal joints, the metacarpo-phalangeal joints become extended and the interphalangeal joints flexed. This deformity is most marked in the last two fingers, for there we have concomitant paralysis of the inner lumbricals (Fig. 6).

FIG. 6.—Shrapnel wound, upper third of arm, involving ulnar nerve. Characteristic ulnar deformity nine months after injury. Has had no treatment.

The musculo-spiral nerve, in the forearm, supplies the supinator longus and the extensor carpi radialis longior. Through its posterior interosseous branch it supplies all other extensor muscles of the wrist and hand and the supinator brevis. The radial nerve is purely sensory. A patient who has a complete lesion of the musculo-spiral nerve cannot extend his wrist; a patient whose lesion is confined to the posterior interosseous branch cannot extend his fingers at the metacarpo-phalangeal joints.

With each nerve, sensory disturbance corresponds, of course, with the cutaneous distribution. Protopathic loss (*i.e.*, loss to pin-prick) is usually less extensive than epicritic loss (*i.e.*, loss to touch of absorbent cotton). Sensation to deep pressure and to joint movement may persist when the first two are non-existent. In the case of the median, total anaesthesia is rare. Usually one finds blunted sensation. Not infrequently this blunted cutaneous area is hypersensitive to pressure. Severe, spontaneous pains are characteristic; they are aggravated by extreme degrees of temperature, by pressure, or by unexpected jarring. These pains may irritate a patient more or less con-

stantly for weeks or months, and for them I know no adequate means of relief. Not infrequently, too, the affected sensory area is cyanotic and perspires freely. All these features are characteristic of the median; in ulnar and musculo-spiral division they are not so marked.

Sometimes, when a nerve is not divided but is surrounded by scar tissue, it is irritated and one sees over-activity rather than paralysis of the controlled muscles. A tightly clenched hand, for example, suggests median irritation (Fig. 7). In such instances exploration is indicated.

FIG. 7.—Bullet wound, inner surface of right arm, July 23, 1916. Operation on April 22, 1917. Median nerve buried in scar tissue but intact.

In actual practice a diagnosis is ordinarily made by the following routine:

1. Observe regions of atrophy, cyanosis, or of undue perspiration.
2. Observe deformities.
3. Request a patient to make simple movements: to pronate the forearm, flex the terminal phalanx of the thumb and oppose the thumb to the palm (median); to abduct and adduct the little finger (ulnar); to extend the wrist and to extend the fingers at the metacarpo-phalangeal joints (musculo-spiral). I have simplified these tests as much as possible; a more comprehensive series of tests can, of course, be readily worked out.
4. Determine loss of sensation (*a*) with a pin and (*b*) with a fluffy bit of absorbent cotton.
5. Verify findings by the responses of the several muscles to faradic (or galvanic) stimuli, applied to motor points on the muscles. I have come to rely more and more on these electrical findings. Twice I have operated against the advice of my colleague of the electro-therapeutic department, and on both occasions he has been right. I was dealing presumably with a contused nerve on each occasion,—with extravasation of blood into a nerve sheath,—and not with actual section of a nerve.

b. Treatment of Nerve Lesions. If, on the other hand, a nerve is wholly or partly divided or is embedded in scar, operation is advisable. So handicapped, a nerve may make a heroic effort but it cannot rejuvenate itself. From this rule we may except, as we shall presently see, an occasional ulnar or median lesion; we may except the case of a nerve troubled so slightly by scar tissue that the resulting symptoms are infinitesimal. Otherwise the rule is absolute. At operation, scar tissue must be eradicated, even to the extent of dissecting free individual nerve fibrils; it serves no useful purpose merely to score a few longitudinal slits in a nerve sheath. For complete division, unless too lengthy a section of nerve has been destroyed, and for partial division, as well, one ordinarily resorts to nerve suture. Remember that the musculo-spiral almost invariably gives good results, the ulnar and median rarely.

Nerves may be sutured with fine catgut, with silk or with linen; most operators prefer catgut. The joined surfaces may be dropped into place without covering or may be surrounded by a thin slice of adjoining muscle tissue; no foreign membrane should be introduced as a covering. Let me repeat: Do not surround the joined nerve surfaces with Cargile membrane or with any other foreign membrane or fascia. Catgut sutures should penetrate only the nerve sheath. Scarred nerve must be freely excised with a very sharp knife until wholesome fibrils are developed in both proximal and distal portions. Exposed nerves must always be handled with extreme delicacy. A tourniquet may be used (Fig. 8). Up to the present, nerve transplantations have not proved successful; nor have attempts to regrow a nerve through a glass, a celluloid or a collodion tube, in those unfortunate cases where a lengthy section of nerve has been destroyed.

In late cases,—and one is usually confronted with these nerve lesions long after the original injury,—quite as important as suture of the

FIG. 8.—Musculo-Spiral Paralysis. Nerve sutured Oct. 12, 1916, upper third right arm. Complete recovery in nine and one-half months.

nerve itself, is the preparation of muscles and joints to receive newly awakened impulses. This will not be a difficult task if splinting has been intelligent from the beginning; unfortunately not a few cases exhibit characteristic contractures. Every effort must be made, then, to restore mobility in joints, to maintain proper muscle tone in stiffened muscles, to free, if need be, muscles from the thongs of scar tissue, to place paralyzed muscles in a position of relaxation. For adjuncts, after operation, we have daily massage and electrical stimulation, which are, perhaps, of service. I say perhaps. As for the form of electricity, faradic shocks should be used if the given muscles will react to faradism; if they will not, the galvanic current must be substituted. A current should be just strong enough to produce contraction, not enough to cause pain. I would lay greater stress, however, on the mechanical correction of existing deformity and the maintenance of paralyzed muscles in a position of absolute rest. This connotes proper splinting.

Every case of paralysis from nerve injury demands a splint and this splint must be used continuously until recovery has taken place or has been despaired of. Let me quote the dictum of Sir Robert Jones:

"When deformity has been corrected the limb should be kept immovable until the ligaments, muscles, and even bone have become of normal length and shape. The continuity of treatment must be maintained or a relapse will result. This point is fundamental, and neglect to observe it spells failure, as the slightest stretching of a muscle on the point of recovery disables it again. All the good work may be thwarted by a single indiscretion. I cannot emphasize this point too strongly. For instance, let us take the case of a drop-wrist which has been placed in a splint designed to dorsiflex the hand at the wrist. The position must be constantly maintained. The hand must not be allowed to flex for a single moment until recovery has occurred. Even while the patient washes, the hand must be held dorsiflexed." (Fig. 9.)

FIG. 9.—Musculo-spiral paralysis. Tendon transplantation in May, 1915. Discharged from hospital *without a splint*. Condition above in January, 1918.

Occasionally one finds, especially with wrist-drop, that this relaxation leads to complete recovery; in other words, the paralysis is apparent, not real. If a surgeon suspects this condition of affairs, he should maintain relaxation indefinitely until he has either been rewarded by a return of normal function or has disproved his suspicion. Three times I have cured complete wrist-drop by immobilization in a dorsi-flexed position for a few weeks.

A suitable splint for paralyzed muscles must accomplish four things:

1. Prevent overstretching of the paralyzed muscles, whether from gravity or from contracture of the opposing muscles.

2. Prevent deformities from contracture of opposing muscles.

3. Allow for treatment,—dressings, massage, even harmless movements,—without removal of the splint.

4. Permit free circulation in the splinted area.

Consider, again, paralysis following musculo-spiral severance. For this paralysis, one would use, preferably, a long cock-up splint which dorsiflexes the wrist and extends both fingers and thumb. A short cock-up splint is contra-indicated because it permits flexion of the fingers. And so for each injury a splint may be evolved which will comply with the above conditions. Stock splints are too often unserviceable; one is frequently better satisfied to mould from plaster an individual splint to meet the requirements of an individual case.

I have implied that nerve suture, on occasion, is impracticable. For this dilemma tendon transplantation at once suggests itself, and the following methods have been found most adequate for each of the nerves that we have considered. Again I quote from Sir Robert Jones:

"*Median Nerve.*

a. The outer tendons of the flexor profundus are inserted into the inner tendons of the same muscle.

b. The tendons of the flexor sublimis are inserted into the tendon of the flexor carpi ulnaris.

c. The extensor carpi radialis longior is attached to the flexor longus pollicis.

Ulnar Nerve.

a. The two inner tendons of the flexor profundus are attached to the two outer.

b. The palmaris longus is inserted into the tendon of the flexor carpi ulnaris.

Musculo-Spiral Nerve.

a. The flexor carpi radialis and the flexor carpi ulnaris are transplanted into the paralyzed extensor of thumb and fingers.

b. The pronator radii teres is affixed to the two radial extensors."

I do not necessarily expect you to remember these details nor shall I describe the technique of the several operations. But I do wish to iterate this salient fact: that in case of irreparable injury to a forearm nerve, good results may be obtained by tendon transplantation (Fig. 10). As for the median, one or two able surgeons no longer

FIG. 10.—Musculo-spiral paralysis. Transplantation of flexor ulnaris and flexor radialis into extensor tendons (without cutting extensors). Can hold wrist easily in this position and further extend 15°.

suture but resort to transplantation at once. Many hands with ulnar lesions have fairly good power, and as neither suture nor transplantation is thoroughly satisfactory, it is an open question whether operation should be advised or deprecated; if function is adequate for the work that a patient must do, I usually deprecate operation. In the case of the musculo-spiral, always suture if possible. Whenever nerve suture is contemplated but, at operation, cannot be carried out, a surgeon must be prepared forthwith to proceed with the appropriate tendon transplantations. The after-care of these cases is, of course, along the lines of that already described for nerve suture.

IV. FUNCTIONAL PARALYSES.

We have seen that some cases of supposed paralysis are not real,—are not due to nerve destruction,—but are due rather to muscle fatigue. We come now to another group that is unreal, the so-called functional cases (Fig. 11). In these no injury to nerve or to muscle can be de-

FIG. 11.—Functional lesion. Bullet wound, right arm. Fingers at first flexed into palm. Now straight but immobile. Electrical reaction normal.

tected; for them operation is of no avail. They yield, if they yield at all, to reëducation and to psychotherapy. One may usually diagnose them readily on the following data:

1. The defect is one of movements of the part as a whole rather than defect in a particular muscle group.

2. Deep reflexes are normal and always present.

3. There is absence of muscle atrophy.

4. One never finds combined, a paralysis of definite muscles and loss of sensation in a corresponding area. Our patient, in other words, exhibits a profound ignorance of nerve distribution.

5. One never finds the exact distribution of a sensory nerve mapped out by anaesthesia. Commonly there is complete anaesthesia below a given level.

6. Finally, the electrical reaction shows no degeneration.

It is essential to exclude the malingerer and to detect the combination of a functional lesion with an organic lesion.

V. SUMMARY OF PAPER.

So far, so good. The points that I would emphasize are these. One must distinguish first between recent wounds and old wounds. With recent wounds, especially of soft tissue, delayed primary or secondary suture,—if possible a partial primary suture,—are the methods of choice. Joints which are not involved, either directly or indirectly, must be kept mobile by daily movement and by massage. Otherwise, while still retaining their integrity, they will quickly become stiff, and careful, gradual manipulation will be required to re-limber them. Joints which are so extensively involved that they are on the road to anchylosis must be placed in those positions which, with anchylosis, will give the most satisfactory functional results.

Too frequently in old cases, one sees deformities and loss of function. In these, where joints are not involved either directly or indirectly, benefit may sometimes be had by gradual mobilization. Joints which are not involved directly, but whose governing tendons are invalidated, are occasionally helped by tendon transplantation, followed by mobilization. If mobilization is impossible it is occasionally necessary to fall back on amputation. Puttering methods of reconstruction are futile.

I have considered, further, a simple method of differential diagnosis among nerve lesions and the differentiation of organic and functional lesions. I have emphasized the importance of preparing an affected region to receive anticipated nerve recovery; by electrical stimulation, by massage, and by proper and continuous splinting. A proper splint must be worked out on an anatomical basis, to the end that it may provide absolute rest for paralyzed muscles and may prevent or correct contracture.

To my mind prevention of contracture is an all-important factor; and it is certain that if hand lesions are treated intelligently from the beginning, if suitable splints are applied, impairment of function may largely be avoided. So that, if this paper be of any value, its worth is derived from the fact that it calls attention to prevention, rather than from suggestions about diagnosis and operative treatment that interleave the text.

THE RELATIONSHIP OF FRACTURE OF THE LOWER EPIPHYSIS OF THE TIBIA TO ARREST OF GROWTH OF THE BONE.*

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AN x-ray photograph of an injury to the lower epiphysis of the tibia was recently shown to me by Mr. H. Blakeway, and although I do not suppose that the injury is new, in the sense of being unrecorded, I think that it is worth describing, as it gives an explanation of the appearances seen in many cases of partial arrest of growth of the bone at this point. (Fig. 1.)

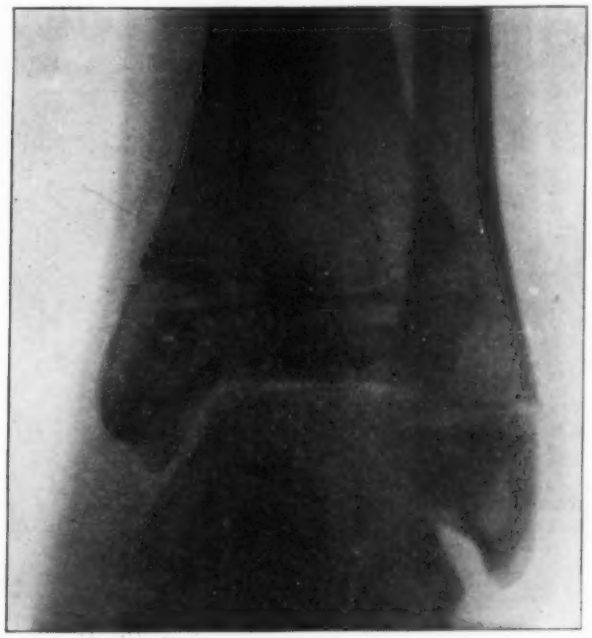

FIG. 1.—X-ray photograph of the ankle showing vertical fissure through lower epiphysis of the tibia.

The accident occurred to a young man, aged 17, whilst skating, the foot being twisted violently inwards. The x-ray shows a vertical fissure in the lower epiphysis of the tibia opposite the prominent outer side of

* A paper read before the British Orthopædic Association.

the upper articulated surface of the astragalus. Such an injury must have been produced by an inward leverage of the internal malleolus, and in order that a fissure of the nature shown might occur it is essential that it should be accompanied by a further fissure running inwards in the manner shown in the diagram. This fissure is too slight to be shown in the x-ray, but it would almost certainly occur through the line of least resistance, that is, through the new bone close upon the diaphyseal side of the epiphyseal cartilage. We have here, therefore, a vertical fissure through the epiphysis at its thinnest point, accompanied by a partial separation of the inner part of the epiphysis. (See Fig. 2.)

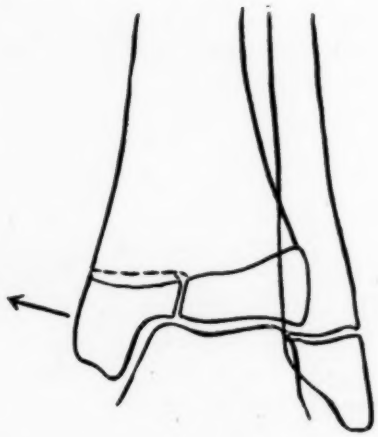

FIG. 2.—Diagram of the complete fracture. The dotted line represents the presumed completion of the line of fracture; the arrow, the direction of the force.

Arrest of growth of a bone due to injury in the region of an epiphyseal line is due to the fact that such an injury leaves a scar across the new bone at the extremity of the diaphysis. The actual growth of the bone at the epiphyseal line is due to the ingrowth of vascular loops furnished with osteoblasts from the cancellous spaces of the extremity of the diaphysis into the proliferating cartilage of the epiphyseal line. The existence of a scar will diminish the rapidity of such an ingrowth or, perhaps, even stop it altogether. Therefore, in this

case we may expect an arrest or a diminution of the growth at the inner side of the epiphyseal line, with a normal rate of growth at the outer part of this line. This is exactly what is seen in those cases of arrest of growth of the lower end of the tibia in which a varus deformity arises. I here show an x-ray photo of such a case of epiphyseal interference, in which it will be seen that there is a sclerosed patch just in the situation which would have been occupied by a fracture such as I have described, and an evident difference in the rate of growth at the inner and outer part of the epiphyseal line. (Fig. 3.)

Of course I am aware that in order to prove conclusively this theory of the origin of interference with the growth of the lower end of the epiphysis I should show a case of this fracture followed, after an interval by arrest of growth and varus deformity. But such a case may be difficult to find, for the injury is, no doubt, uncommon, and in most cases of arrest of growth there is no radiographic evidence of the nature of the original injury. I am in hopes that some of my audience may be able to complete the case by finding and recording a complete case.

FIG. 3.—Arrest of growth of the lower epiphysis of the tibia with varus deformity.

DISCUSSION.

MR. MCMURRAY: I have had a case under notice for five years which had the same injury as Major Elmslie has described, the fibula now being almost on the sole. Osteotomy has been done on tibia on the inner side on three occasions, and it is perfectly straight and shows a mark along the epiphyseal line due to the fibrous partition. It was a transverse fissure, right across, but the edge of the epiphysis was broken towards the right fibula and there is a transverse fracture between.

MR. BENNETT: I think we should be able to find many of these cases among our patients, that is, those in which we have manipulated with a wrench and probably got, as a result, some fracture. I think in many cases we do alter the epiphyseal line of the lower extremity. I have seen cases in which there has been prolongation of the fibula.

GENERAL SIR ROBERT JONES: On more than one occasion I have separated the epiphysis in some of my rather rough and primitive surgery, yet in no instance have I noticed any bad effect. What struck me as extraordinary and interesting is, that I have notes of cases, and other cases I remember, which had suppuration and separation of the epiphysis, and growth has occurred just the same. Of course one has noted cases where growth has been interfered with by an injury of the epiphysis. In one case, I remember, a huge abscess was opened and I found the epiphysis was separated. Seven years afterwards I examined the limbs and there was not the slightest difference in their length. So it is probable that many injuries of the epiphysis do occur, which do not, however, rise up like a ghost before us in later days.

THE PRESIDENT: As confession seems to be rather the order of the day, I may confess to having had an exactly similar experience to Sir Robert Jones'. I have, several times, separated the epiphysis of the lower end of the tibia in forcible manipulation of club-foot but have never been able to find any alteration in the growth afterwards. It is rather sad that both the President and the Vice-President of this Association should be guilty of rough and primitive surgery, but the fact remains.

RESULTS OBTAINED BY TREATING WEAK FEET ALONG MILITARY LINES AMONG CIVILIANS.

BY LEO C. DONNELLY, M.D., DETROIT,
Ex-Director Orthopædic Surgery, Camp Wheeler.

THE author has been acting as orthopædic member to Medical Advisory Board No. 21, and as medical member to Local Board 10, for the past several months. This work has brought him in contact with nearly as many cases of weak feet as did his active military service in Base Hospital No. 43 Bis, in France, during 1916 and 1917, and later as director of orthopædic surgery at Camp Wheeler. During the months of June and July, one saw as high as fifty cases a day of weak feet at the Medical Advisory Board, and ten to twenty per day at the Local Board.

Nearly 100 per cent. of the registrants with defective feet appeared for examination wearing the so-called English walking shoe, a narrow-toed shoe. On questioning those who appeared wearing a broad-toed shoe, nearly all gave the history of having worn previously the narrow-toed shoe. Many still wore the narrow-toed shoe as a dress shoe. A large number of men rejected by the local Navy and Marine recruiting stations presented themselves at the office, hoping that some method could be devised to build up their feet so that they could pass the physical examination for induction in the respective services.

The author, being conversant with the method employed by the American, British and French Medical Corps, thought that similar methods could be applied to civilians with equally good prospects of success. The lack of military control over the patients was counterbalanced by the desire of these young men to get into service. Civilian life being less arduous than military life also worked to the patient's advantage.

The patients were told that their feet were weak chiefly because of poor-fitting shoes, faulty standing posture and undeveloped foot muscles. The muscle pull of the foot flexors, foot extensors and foot supinators were taken each week and the patient kept informed of the progress. He was told that the military shoe was considered the most perfect shoe made and that he must wear that shoe all of the time while under treatment. The patients were fitted according to the rules laid down by the Surgeon-General's Office, excepting that they did not have a 40-pound pack upon their back. Their former shoes were

too short or too narrow, many both too short and too narrow. All complained that the new army shoes were too large, but admitted that they were the most comfortable that they had worn. Since bromidrosis was pronounced with these patients, they were supplied with a formaldehyde solution in which to soak their feet, and with a foot powder containing boric acid and salicylic acid. The bromidrosis usually disappeared within two weeks. The patients were shown on the skeleton that the arrangement of the metatarsals and phalanges of the foot is similar to the corresponding bones of the hand; that since the bone, blood, nerve and muscle supply of these parts is very similar, one should expect that training would tend toward making their function similar. They were told that in order to train the muscles of their feet properly, they had to stand with feet parallel, throwing the body weight toward the outer border of the feet, that when the muscles of the feet were well developed by exercises, the muscles would fill the spaces of their feet by their bulk, and that their contractile power would approximate the bases of the arches of the feet, and then their weak feet would be cured. They were also informed that shifting their body weight would temporarily produce new tender points and that corns and callouses did not exist among properly shod soldiers, and that theirs would disappear.

In order to allow the patient to intelligently coöperate he was given a printed sheet with full directions and explanations. He was to do his exercises 30 times, morning and night, and as often during the day as practicable. The five principal exercises consisted of flexion and extension of the toes over a board, separating toes, standing with feet parallel fourteen inches apart and internally rotating legs and supinating feet until the toes touched and the body weight was entirely on the outer borders of the feet, sitting with knees crossed and rotating foot inward in large circles, seeing that each tendon showed in turn; sitting, feet widely spread, toes in, forcing feet forward in a crescentic manner until toes touched, then pulling them back in opposite manner. Many other less valuable exercises were added for their psychic effect. Those that reported three times a week progressed proportionately faster than those who reported once a week. Every patient, except one, passed the Navy and Marine Corps examination within two months, the majority within three weeks; over fifty have passed the Marine Corps alone.

These patients were young Americans who wanted to enlist and who felt that to be drafted was a disgrace. They were keen for the service and would do anything asked of them if it aided their chances

of passing. All feet improved remarkably in muscle strength, some arches raised 5/8 inches by actual measurement. The gratefulness expressed by these 18 and 19-year-old boys on passing into their respective corps amply repaid one for the energy expended in directing them.

The same plan has been tried on older patients, with satisfactory results. They have not the fire of youth and are willing to stop exercising as soon as the pain and foot disability are relieved. This plan of treatment has given definitely better results than the author's former method of supplying arches made from casts. In fact the author is attempting to eliminate foot plates as much as possible.

In closing, it seems to the author that the Government, for military reasons, should standardize the lasts upon which shoes are built, so as not to allow people to ruin their feet. A national board, having an orthopædic member from the Surgeon-General's office, could pass on lasts before the shoes were built.

The following brief case histories are appended:

CASE 1	FOOT FLEXORS	FOOT SUPINATORS	FOOT EXTENSORS	BROMIDROSIS	CALLUSES	COMFORT
Aug. 8	24 lbs.	22 lbs.	32 lbs.	Severe	Not noted	Tired
Aug. 28	46 lbs.	48 lbs.	46 lbs.	Improving		Less tired
Sept. 4	46 lbs.	48 lbs.	56 lbs.	None		Not tired
Sept. 9	62 lbs.	56 lbs.	70 lbs.	None		Feels fine
Sept. 10	Passed Navy examination. Previously rejected.					
CASE 2						
July 31	20 lbs.	20 lbs.	24 lbs.	Severe	Ant. arch	Burns, tired
Aug. 8	30 lbs.	30 lbs.	34 lbs.	None	Small	Less tired
Aug. 13	Passed Navy examination, previously rejected, wore arch supporters.					
CASE 3						
Aug. 1				Severe	No record	Tired
Aug. 6				Improved		Feels fine
Aug. 23	46 lbs.	48 lbs.	48 lbs.	None		Feels fine
Sept. 5	52 lbs.	58 lbs.	60 lbs.	None		Feels fine
Sept. 15	64 lbs.	68 lbs.	64 lbs.	None		Feels fine
Sept. 16	Passed Navy examination, previously rejected.					
CASE 4						
Aug. 8	28 lbs.	18 lbs.	40 lbs.	Severe	Ant. callous	Tired
Aug. 15	40 lbs.	32 lbs.	50 lbs.	Less	Less	Improved
Aug. 19	42 lbs.	38 lbs.	50 lbs.	Less	Less	Feels good
Aug. 30	56 lbs.	48 lbs.	58 lbs.	None	None	Feels good
Sept. 5	Passed Navy examination, previously rejected.					

SPLINT DEVISED FOR TREATMENT OF STIFF METACARPO-PHALANGEAL JOINTS.

BY FRANK E. LEWIS, CAPTAIN, M. C., U. S. A., LIVERPOOL,
Alder Hey Military Hospital.

THIS splint was devised for the treatment of stiff metacarpo-phalangeal joints. The large number of such cases has given the surgeon much trouble, inasmuch as treatment has produced very slow and uncertain results.

These stiff joints occur in practically all cases which require long application of splints to the forearm and hand, and persist in spite of massage or manipulation.

Compound fractures of the forearm, involving tendons, fracture of the carpal bones, with tendon involvement, injury to the metacarpals and paralysis of muscles from nerve injury all tend to bring about

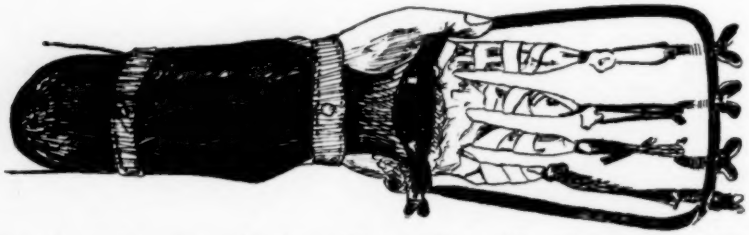

FIG. 1.—Under view, showing splint applied with extension to finger.

FIG. 2.—Side view, showing method of fixation to forearm and dorsal flexion of wrist.

atrophic change in the metacarpo-phlangeal joint, with a resultant hyperextension and dislocation. At the same time, the anterior arch of the hand becomes convex and painful. In most of these cases there is also a stiff wrist.

In devising this splint, the principal object was to get flexion of the metacarpo-phalangeal joints in the shortest time possible, by following the mechanical principle of traction and countertraction. Diagram No. 2 shows the splint in outline, demonstrating the method of attaining traction and countertraction.

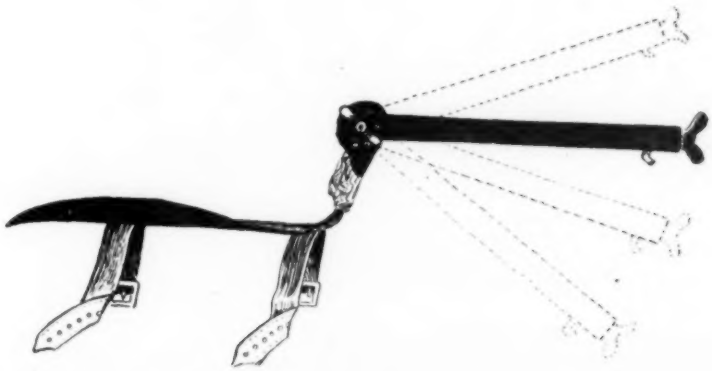

FIG. 3.—Cross section, showing method of flexing fingers at metacarpo-phalangeal joints while in extension.

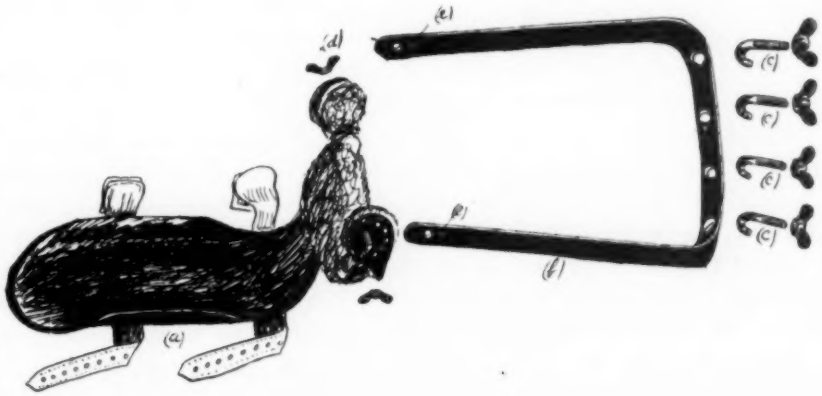

FIG. 4.—Showing individual parts of splint: (*a*) Splint for dorsal flexion of wrist; (*b*) Frame for flexion of fingers at metacarpo-phalangeal joints; (*c*) Extension screws. (Individual as desired.); (*d*) Screws for flexion frame; (*e*) Pin for fixation of frame in position desired.

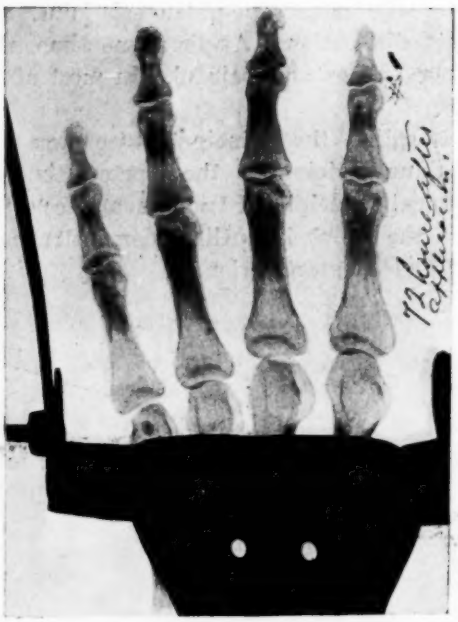

FIG. 5.

As was mentioned above, we find a stiff wrist in a majority of these cases—the dorsal flexion is obtained, first, by the cock-up part of the splint and, secondarily, by the gradual countertraction marked by the arrow.

As the traction is applied to the fingers, there is a resultant countertraction on the wrist, producing dorsal flexion.

The bar which comes just back of the metacarpal heads is curved so as to preserve the natural anterior arch of the palm. The extension is applied to the fingers for 48 hours, then the flexion frame, as demonstrated in figure No. 3, is lowered gradually each day and held in position by thumb screw (d) in diagram No. 4. It is essential that the extension straps should be carefully applied to the fingers so that there will be no slipping. Adhesive strapping should be used.

The stiffness of the phalangeal joints improves as the deformity of the metacarpal joints is reduced, and can be hastened by loosening the individual extensions daily for about ten minutes, while the fingers are being massaged. The results have been particularly gratifying in long-standing cases.

FIG. 6.

The x-ray showing the splint applied was taken 72 hours after application. Comparison with the x-ray of the same patient 14 days after application of the splint, shows how well the joints have been reduced, there being 60° of voluntary flexion.

The flexion frame can be applied with equal success to flexion deformities by reversing the procedure, *viz.*, by applying the frame in flexion and gradually extending fingers by raising the frame.

THE CHANGES PRODUCED IN THE GROWING BONE AFTER INJURY TO THE EPIPHYSEAL CARTILAGE PLATE.

BY S. L. HAAS, M.D., SAN FRANCISCO,

Captain, Medical Corps, U. S. Army.

[From the Pathological Laboratory and the Surgical Pathological Laboratory of Leland Stanford, Jr., University School of Medicine.]

(*Concluded from page 179.*)

Experiment 65. 15 Days. Dog 72-56.

Operation. Removed the proximal diaphyseal end of the metacarpal III., of the left fore foot. The total length is 2.2 cm., while the part remaining is 1.25 cm. The animal died at the end of 15 days.

Gross Findings. There is good healing. The bone on longitudinal section appears paler than normal. The epiphyseal cartilage plate appears normal. The measurements are: Metacarpal III., at end of experiment, 1.3 cm.; metacarpal III., at operation, 1.25 cm.=0.05 cm. Thus there is no growth in this short period.

Experiment 66. 42 Days. Dog 108-71.

Operation. Removed the proximal two-thirds of the metacarpal III. of the right fore foot. The total length of the bone is 2.8 cm., while the part remaining is 1.2 cm. The animal died at the end of 42 days.

Gross Findings. There is a change in the shape and size of the bone. The cut end is small and rounded off, but possesses medullary contents up to the end. The cut end is small and epiphyseal cartilage plate appears normal. The measurements are: Metacarpal III., at end of experiment, 1.85 cm.; metacarpal III., at operation, 1.2 cm. Thus there is 0.65 cm. increase in length since the operation. The normal growth is 3.45—2.8=0.65 cm.

Experiment 67. 50 Days. Dog 97-68.

Operation. Removed the proximal part of the metacarpal IV. of the right fore foot. The piece remaining measures 0.7 cm.

Gross Findings. There is good healing. The epiphyseal cartilage plate is of normal appearance. The cut end is pointed and there is a tendency to form a new cortex. The measurements are: Metacarpal IV., at end of experiment, 1.1 cm.; metacarpal IV., at operation, 0.7 cm.=0.4 cm. Thus there is only relatively a small amount of growth.

Microscopical Findings. The epiphysis appears normal. The epiphyseal cartilage plate is not so regular as normal, and there is not the usual active ossification of the cartilage columns of the epiphysis. The cut end of the bone has assumed a conical shape and is enclosed by fibrous tissue. No definite cortex is present at the end of the bone but there are some irregular pieces of osseous tissue within the limiting fibrous tissue.

Experiment 68. 68 Days. Dog 119-75.

Operation. Removed the proximal portion of metacarpal III. of the left fore foot up to the metaphyseal region. The total length of the bone is 3.2 cm., while the piece remaining is 1.65 cm.

Gross Findings. The general appearance of the bone, including the epiphyseal cartilage plate and marrow is normal. The measurements are: Metacarpal III., at end of experiment, 2.35 cm.; metacarpal III., at operation, 1.65 cm.=0.7 cm. of growth. The roentgenogram shows the end of the bone limited by cortical bone. The medullary canal has a fairly normal appearance. (See Fig. 10.) The normal growth is 4.2—3.2= 1.0 cm.

Experiment 69. 126 Days. Dog 88-64.

Operation. The basal portion of metacarpal IV. of the left fore foot is removed up to the metaphyseal region. The part remaining measures 1.0 cm.

Gross Findings. There is good healing. The bone has increased in length but is narrower at the cut end. This is well shown in the roentgenogram. The epiphysis of the operated bone is only slightly smaller than normal. (See Fig. 11.) The measurements are: Meta carpal IV., at the end of experiment, 2.25 cm.; metacarpal IV., at operation, 1.00 cm. Thus there is an increase of 1.25 in length since the time of operation.

SUMMARY ON CUTTING THROUGH THE METAPHYSEAL REGION AND REMOVING THE PROXIMAL PORTION.

In practically every instance there is evidence of growth. If the incision approaches close to the epiphyseal cartilage plate there is a considerable hindrance of growth. The growth is not so great as normal, due to two factors. First, because of the destruction of the vascular supply coming from the nutrient artery and part of the direct supply to the epiphyseal cartilage plate. Secondly, because of the direct injury to the cartilage plate itself.

FIG. 10.—Experiment 68. 68 days. Dog 119-75. Removal of the proximal portion of the metacarpal. Right in photograph, B, third bone from the right, 3, is the operated bone. Notice how the cut end of the bone is enclosed with an even and rounded new cortex of normal structure.

FIG. 11.—Experiment 69. 126 days. Dog 88-64. Removal of the proximal portion of the metacarpal. The cut end of the operated bone, 4, has assumed a pointed form. There is considerable rarefaction of the shaft most likely due to destruction of some of the blood supply.

TABLE XVII.

EXP. NO.	DOG NO.	DURATION	GROWTH OF OPERATED	LOSS OF GROWTH	GROWTH OF NORMAL
64	76-5	15 days	0.05 cm.	0	0
65	72-56	15 "	0.05 cm.	0	0
66	108-71	42 "	0.65 cm.	0	0.65 cm.
67	97-68	50 "	0.4 cm.	?	?
68	119-75	68 "	0.7 cm.	0.3 cm.	1.0 cm.
69	88-64	120 "	1.25 cm.	?	?

The following additional experiments have been performed and will be described in order.

GROUP VII. BORING INTO AND REMOVING THE CANCELLOUS BONE OF THE EPIPHYSIS.

1. Boring Directly Into the Epiphysis.

Method. After exposing the epiphysis of the selected bone a small hole is made through the cortex of the epiphysis. By means of a small curette the cancellous bone of the epiphysis is removed.

Experiment 70. 33 Days. Dog 114-73.

Operation. Removed the cancellous tissue from the epiphysis of the metatarsal IV. of the left hind foot. The bone measures 2.9 cm.

Gross Findings. There is good healing. The opening in the epiphysis is still visible. There is some new bone within the cortex. The measurements are: Metatarsal IV., at end of experiment, 3.2 cm., metatarsal IV., at operation, 2.9 cm. There is 0.3 cm. of growth since operation. The normal growth is 3.2—2.9=0.3 cm.

Microscopical Findings. There is considerable cancellous bone in epiphysis. The opening in the cortex is filled with fibrous tissue and some cartilagenous tissue. The epiphyseal cartilage plate appears fairly normal. The remainder of the bone appears normal.

Experiment 71. 65 Days. 107-70

Operation. Scraped out the cancellous bone of the epiphysis of the metatarsal IV. of the left hind foot. The bone measures 3.1 cm. The animal died at the end of 65 days.

Gross Findings. The joint capsule is thickened. On longitudinal section the epiphysis is found to be practically normal in appearance. There is no evidence of the hole in the cortex. The measurements are: Metatarsal IV., at the end of experiment, 3.95 cm., metatarsal IV., at operation, 3.1 cm. Thus there is 0.85 cm. of growth. The normal growth is 4.0—3.1=0.9 cm.

Microscopical Findings. The general appearance of the epiphysis is normal. The hole in the cortex cannot be made out. There is a defect in one portion of the epiphyseal cartilage plate. This might be due to an accidental injury at the time of operation. The ossifying buds of the metaphysis are shorter and fewer than normal.

SUMMARY ON DIRECTLY REMOVING TISSUE OF THE EPIPHYSIS

There is no hindrance of growth after such an operation. This would naturally be expected as there is no injury to the epiphyseal cartilage plate, and but slight injury to the epiphyseal blood supply.

TABLE XVIII.

EXP. NO.	DOG NO.	DURATION	LOSS OF GROWTH	GROWTH OF OPERATED	GROWTH OF NORMAL
70	114-73	33 days	0	0	0.3 cm.
71	107-60	65 "	0.05 cm.	0.85 cm.	0.9 cm.

2. Boring into the Epiphysis Through the Epiphyseal Cartilage Plate.

Method. A small opening is made through the cortex of diaphysis near the metaphysis. Then by means of a small curette an opening is made through the epiphyseal cartilage plate in the epiphysis. The cancellous bone is then removed from the epiphysis. The wound is closed in the usual manner. In this experiment there is practically no destruction of the epiphyseal blood supply.

Experiment 72. 16 Days. Dog 64-58.

Operation. Bored into the epiphysis of the metacarpal III. of the left fore foot through the epiphyseal cartilage plate.

Gross Findings. The bone is bent just on the diaphyseal side of the metaphysis. On longitudinal section it is noticed that only the central portion of the epiphyseal cartilage plate is removed. The marrow of the epiphysis has a fairly normal color and appearance. The measurements are: Metacarpal III., left, 2.05 cm.; difference, 0.25 cm. right, 2.3 cm. Thus there is a loss in growth of 0.25 cm.

Microscopical Findings. There is a defect in the epiphyseal cartilage plate which is occupied by marrow and trabeculae of normal structure. There is no difference in the structure of the epiphysis except a diminution in the number of trabeculae. The hole in the cortex of the diaphysis is filled with fibrous tissue.

Experiment 73. 28 Days. Dog 145-85.

Operation. Performed a similar operation as in Experiment 72 upon the metacarpal III. of the left fore foot. The length of the bone at operation is 2.3 cm. The animal died at the end of 28 days.

Gross Findings. On longitudinal section a yellowish area is noticed within the epiphysis. The epiphyseal cartilage plate is straight instead of curved and is not so distinct as normal. There is a small defect in the central part. The remainder of the bone appears fairly normal. The measurements are: Metacarpal III., left, 2.6 cm.; difference, 0.6 cm.; right, 3.2 cm. Thus there is 0.6 cm. loss of growth.

Microscopical Findings. There are very slight changes in the epiphysis. There is a defect in the center of the epiphyseal cartilage plate, which is filled with marrow and trabeculae. The cartilage plate is narrower than normal and the columns of cartilage are irregular. There is almost a complete absence of the ossifying columns of the metaphysis and the general indications point to a cessation of growth The diaphysis appears fairly normal.

Experiment 74. 30 Days. Cat 74-47.

Operation Bored into the diaphysis of metatarsal III. of the right hind foot and then curetted out the epiphyseal cartilage plate from the inside. The animal died at the end of 30 days.

Gross Findings. The measurements are: Metatarsal III., left, 2.5 cm.; difference, 0.1 cm.; right, 2.4 cm. There is practically no difference between the two sides. There has evidently been little growth even in the normal bones.

Experiment 75. 28 Days. Dog 94-66.

Operation. Bored into the diaphysis of the metatarsal III. of the right hind foot and scraped out the epiphyseal cartilage plate from the inside. The animal died at the end of 38 days.

Gross Findings. There is a distortion of the head of the bone on the shaft. On longitudinal section the central part of the epiphyseal cartilage plate is found to be occupied by osseous tissue. The measurements are: Metatarsal III., left, 3.25 cm.; difference, 0.65 cm.; right, 2.6 cm. There is a shortening of 0.65 cm., a part of which is due to the distortion of the head of the bone on the shaft.

Experiment 76. 41 Days. Dog 78-60.

Operation. Bored into the diaphysis of the metatarsal III. of the

left hind foot and scraped out the epiphyseal cartilage plate from within. The animal died at the end of 41 days.

Gross Findings. There is an apparent shortening of the operated bone. On longitudinal section the epiphyseal cartilage plate is found to be almost entirely absent, its place being occupied by osseous tissue. The measurements are: Metatarsal III., left, 3.1 cm.; difference, 0.5 cm.; right, 3.6 cm. Thus there is a loss of 0.5 cm., due to the destruction of the epiphyseal cartilage plate. The Roentgenogram shows the shortening and also the defect in the epiphyseal cartilage plate and the tract of new tissue along the puncture, through the diaphysis into the epiphysis. (See Fig. 12.)

FIG. 12.—Experiment 76. 41 days. Dog 78-60. Removal of the epiphyseal cartilage plate by boring into the diaphysis and scraping the cartilage from within. Right in the photograph, B, third bone from the right is the operated bone. Notice the loss of growth, ascertained by comparing with its fellow, 4, which it should equal in length. The course of the puncture is shown in the shadow in the upper portion of the diaphysis. This experiment shows that an injury to the plate, even with an intact blood supply, will cause growth disturbance.

SUMMARY ON THE REMOVAL OF THE EPIPHYSEAL CARTILAGE PLATE FROM WITHIN.

In five of the six experiments there is a decided hindrance in growth of the bone following the removal of a portion of the epiphyseal cartilage plate from within. This shows that even with an adequate blood supply from without there will be a loss in growth if the epiphyseal cartilage plate is injured. This set of experiments shows the inadvisability of operating through the epiphyseal cartilage plate, as has

been advised in the case of tuberculosis of the head of the femur, or in other bones, especially if it necessitated the injuring of an epiphyseal plate, which is most important in the production of the increase in length.

TABLE XIX.

EXP. NO.	DOG NO.	DURATION	LOSS OF GROWTH	GROWTH OF OPERATED	GROWTH OF NORMAL
72	64.58	16 days	0.35 cm.	?	?
73	145-85	28 "	0.6 cm.	0.3 cm.	0.9 cm.
74	74-47*	30 "	0.1 cm.	?	?
75	94-66	38 "	0.65 cm.	0.1 cm.	0.75 cm.
76	78-60	41 "	0.5 cm.	0.5 cm.	1.0 cm.

*Cat

GROUP VIII. DIRECT TRAUMA TO THE EPIPHYSEAL CARTILAGE PLATE.

1. Crushing the Epiphyseal Cartilage Plate.

Method. The epiphyseal cartilage plate is exposed and then by means of hemostatic forceps the epiphyseal cartilage plate and adjacent bony tissues are crushed.

Experiment 77. 76 Days. Dog 35-76.

Operation. After exposing metatarsal IV. of the right hind foot, the epiphyseal cartilage plate is crushed by means of a hemostat. This procedure necessarily injures the adjacent metaphysis and epiphyseal cancellous bone. The bone measured 2.8 cm. The animal died at the end of 76 days.

Gross Findings. There is good healing. The measurements are: Metatarsal IV., left, 4.55 cm.; difference, 0.5 cm.; right, 4.05 cm. Thus there is a loss of 0.5 cm. in length since the operation. The growth of the normal bone is 1.75 while that of the operated is 1.25 cm. So that in this case there is only a partial hindrance of growth. The roentgenogram shows the difference in size of the normal and operated bone. The greater part of the epiphyseal cartilage plate is intact and has a fairly normal structure. The remainder of the bone appears normal.

Experiment 78. 81 Days. Dog 16-52.

Operation. Crushed the epiphyseal cartilage plate of metacarpal III. of the right forefoot. The bone measures 2.7 cm. in length. The animal was killed by illuminating gas, after 81 days.

Gross Findings. There is some distortion of the articular surface of the operated bone. On longitudinal section there is found to be almost a complete absence of the epiphyseal cartilage plate. The epiphy-

sis itself is somewhat distorted in shape. The metaphysis is denser than normal. The measurements are: Metacarpal III., left, 4.85 cm.; difference, 1.7 cm.; right, 3.15 cm. Thus there is a loss of 1.7 cm. in length since the operation. The growth of the operated bone is 3.15—2.7=0.45 cm., while the normal growth is 4.85—2.7=1.15 cm. Thus in this particular case there is more hindrance in growth than in Experiment 77. Naturally this must be due to a more severe injury to the epiphyseal cartilage plate at the time of operation. The Roentgenogram shows almost an entire disappearance of epiphyseal cartilage plate, also the marked shortening and smaller size of the epiphysis. (See Fig. 13.)

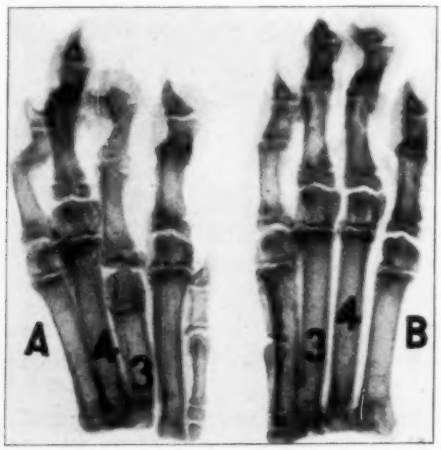

FIG. 13.—Experiment 78. 81 days. Dog 16-52. Crushing the epiphyseal cartilage plate. Left in photograph A, third bone from the left is the operated bone, 3. The epiphseal cartilage plate is ossified and there is a marked loss of growth. Compare 3 and 4, as they are normally equal in length.

Microscopical Findings. The epiphysis has a fairly normal structure. The epiphyseal cartilage plate shows a defect, also a marked distortion. The columns are shorter and irregularly placed, and there is no ossifying buds extending into the metaphysis.

SUMMARY ON DIRECT TRAUMA TO THE EPIPHYSEAL CARTILAGE PLATE.

Although the number of experiments are few, one can make certain definite deductions as to the effects of a crushing injury to the epiphyseal cartilage plate. There is always a hindrance in growth which naturally depends upon the severity of the injury of the epiphy-

seal cartilage plate. The more cells destroyed the greater the amount of growth disturbance. Even in a fairly severe injury there is not a complete cessation of growth, as some of the cells seem to retain a limited property of producing an increase in length.

TABLE XX.

EXP. NO.	DOG NO.	DURATION	LOSS OF GROWTH	GROWTH OF OPERATED	GROWTH OF NORMAL
77	35-76	76 days	0.5 cm.	1.25 cm.	1.75 cm.
78	16-52	81 "	1.7 cm.	0.45 cm.	2.15 cm.

2. Cutting Out a Wedge from the Region of the Epiphyseal Cartilage Plate.

Method. After exposing the epiphyseal cartilage plate by means of a sharp scalpel, a wedge of cartilage is cut out.

Experiment 79. 81 Days. Dog 17-52.

Operation. The Metatarsal III. of the left hind foot is exposed. A wedge which extended about one-half way through the cartilage plate is then excised. The length of the bone is 3.0 cm. The animal was killed by illuminating gas at the end of 81 days.

Gross Findings. There is good healing. The articular cartilage has

FIG. 14.—Experiment 79. 81 days. Dog 17-52. Cutting out of a wedge from the epiphyseal cartilage plate. Right in photograph B, third bone from the right, 3, is the operated bone. Notice the marked disturbance in growth following the removal of a wedge from the cartilage. The epiphyseal cartilage plate has undergone an early ossification and there is a broadening of the diaphysis.

been altered in shape. The epiphyseal cartilage plate is distorted. The dorsal portion which was excised shows no evidence of regeneration. (See Fig. 14.) The measurements are as follows: Metatarsal III., left, 3.2 cm.; difference, 1.9 cm.; right 5.1 cm.; Thus there is a loss of 1.9 cm. in length of the operated bone. The growth of the operated bone is 3.2—3.0=0.2 cm., while that of the normal bone is 5.1 cm.—3.0 cm.=2.1 cm.

Microscopical Findings. The articular cartilage is somewhat uneven but of fairly normal structure. The trabeculae and marrow of the epiphysis are relatively normal. The epiphyseal cartilage line appears as a small remnant on the plantar side. Even this portion of the cartilage has lost considerable of its normal structure and arrangement and is undergoing ossification. The diaphysis is normal.

SUMMARY ON CUTTING A WEDGE SHAPED PIECE FROM THE EPIPHYSEAL CARTILAGE PLATE.

In the single experiment of this nature the injury was so severe as practically to cause a cessation of growth. The portion of cartilage plate remaining did not possess the power to cause a compensatory growth, in fact, it seems to have undergone a rapid calcification.

RÉSUMÉ.

1. Simple Cross Incisions. Simple cross incisions through the epiphysis distal to the epiphyseal cartilage plate, as well as those through the metaphysis or diaphysis, cause no disturbance in longitudinal growth. A cross incision through the epiphyseal cartilage plate always causes a loss of growth, the loss being directly proportional to the degree of injury to the cartilage cells. It is possible to make a separation in the line of cleavage of the cartilage plate without causing any disturbance to growth, but, as a rule, even in cleavage separations there is a hindrance of growth.

2. Longitudinal Incisions. Longitudinal incisions extending through the epiphysis and epiphyseal cartilage plate produce no disturbances in growth. If the longitudinal incision extends through the entire length of the bone there is a slight loss of growth. This loss must be ascribed to an injury to some of the large blood vessels which supply the epiphyseal cartilage plate. There is also the possibility of the additional trauma of the two halves rubbing together because of the greater mobility produced by the incision.

3. Cross Incisions and Raising the Distal Fragment. If the portion distal to the epiphyseal cartilage plate is raised there is no disturbance in growth, unless the incision comes near the vital growing

cells of the epiphyseal cartilage plate. When the incision passes through or a separation is made in the line of cleavage of the epiphyseal cartilage plate then there is a marked hindrance in growth. A small amount of growth occurs after this disturbance, which may be ascribed to potential cell growth of the injured cartilage cells. If the incision passes proximal to the epiphyseal cartilage plate and the distal segment is raised, including the epiphyseal cartilage plate, there is practically a complete cessation of growth. The later experiment is a complete reimplantation of the epiphyseal cartilage plate and epiphysis.

4. Longitudinal Incisions Through the Epiphyseal Cartilage Plate with Removal of One of the Halves. If one lateral half of the epiphysis is removed up to the epiphyseal cleavage line there takes place subsequently little growth in length of that bone. If the section includes a portion of the metaphysis there is likewise a very great loss in length growth. If the entire lateral half of the bone is removed there results a complete cessation of growth of the remaining segment. One would hardly expect to find such a marked degree of disturbance —following the removal of one half of the epiphysis. This disturbance must be ascribed to injury to the blood supply, trauma to the cartilage cells, and disturbance in the growth equilibrium. Because of these facts, it is inadvisable to remove such segments for transplantation as suggested by some investigators.

5. Cross Incisions with Removal of the Distal Segment. There is practically no disturbance in growth when the portion removed is distal to the epiphyseal cartilage plate. If the entire epiphysis up to the epiphyseal cartilage plate is removed then there is practically a complete cessation of growth. In some cases there is an irregular outgrowth of bone, pointed in form, and entirely unlike that which occurs at the normal epiphyseal cartilage plate. If the epiphysis, including the metaphysis is also removed, then there is also a complete cessation of purposeful longitudinal growth. There might occur some irregular sprouting at the cut end, such as one would get along a periosteal remnant.

6. Cross Incisions with Removal of the Proximal Segment. In the case where the separation is made in the line of cleavage with removal of the proximal segment and leaving the epiphysis, there is practically a complete cessation of longitudinal growth. That the intact cartilage of the epiphyseal cartilage plate ceases to functionate seems rather peculiar, but it must be ascribed to the fact that the blood supply to the epiphyseal cartilage plate is almost entirely destroyed in this operation. This de-

destruction of the blood supply, with a certain amount of unavoidable injury to the epiphyseal cartilage plate is sufficient to explain the loss of growing power. If the separation is made in the metaphysis or diaphysis there is a continuance of growth in every instance. However, if the incision approaches too close to the epiphyseal cartilage plate, then there will be disturbance in growth because of the injury to the blood supply of the epiphyseal cartilage plate.

7. *Boring into the Epiphysis.* If one bores a hole directly into the epiphysis and scrapes out the cancellous bone there will be no disturbance in length growth. If, however, a hole is bored into the metaphysis and the cancellous bone of the epiphysis is removed from within, by means of a hole made through the epiphyseal cartilage plate, there is a loss of growth in almost every instance. This is due to the injury to the important cells of the epiphyseal cartilage plate. It is important to bear this fact in mind in trying to operate upon the epiphysis through the epiphyseal cartilage plate, as has been suggested in the cure of tuberculosis of the head and neck of the femur, by boring through the epiphyseal cartilage plate of the neck of the femur; also a like care in any operation involving the epiphyseal cartilage.

8. *Direct Trauma to the Epiphyseal Cartilage Plate.* A direct crushing injury to the epiphyseal cartilage plate always causes a loss of growth. The greater the injury to the cartilage cells and destruction of the blood supply, the greater the loss of growth. In the case of a very severe crushing injury there might not be a complete cessation of growth, as some of the cells might retain their vitality and be capable of proliferating. It is known from other experimental data that excision of the epiphyseal cartilage plate means the cessation of length growth, as length growth depends upon the integrity of this important cartilage. When a wedge of cartilage is removed there is almost a complete loss of growth, because the remaining cells have little power to cause length growth.

9. Having as a working principle that the most active and important elements necessary for longitudinal growth are located in the columns of cartilage of the epiphyseal cartilage plate the above experiments give further substantiation to this fact. Thus it is noticed that the nearer the injury comes to the cartilage columns the greater is the growth disturbance. Also that there is a relation between the degree of destruction of the cartilage columns and loss of growth. These two factors, along with disturbance in blood supply, form the more important principles governing bone growth. Previously it has been shown that destruction of the direct blood supply to the epiphyseal cartilage

plate has a marked hindering of longitudinal growth. Therefore, the result of any injury to the epiphyseal cartilage plate is dependent upon the degree and closeness of the injury to the columns of cartilage and to the amount of destruction of the direct blood supply to the region of the epiphyseal cartilage plate. It is hoped that these facts will be of value in helping to explain and anticipate the outcome, clinically, in injury to the epiphyseal cartilage plate; also to aid us in choosing, or of the advisability of resorting to, certain operative procedures that are associated with this important portion of the growing bone.

I wish to take this opportunity to express my thanks to Professor Ophuls of the Pathological Department for the privilege of performing these experiments under his supervision, and to Professor Blaisdell of the surgical laboratory for his assistance in the operative work and for the many courtesies extended to me during the period of investigation.

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Book Review

The Suspension Treatment of Fractures. By P. Desfosses and Charles-Robert. Paris: Masson et Cie., 1918.

In a preface to this comprehensive monograph Pierre Duval says in part: "The method of suspension justly called the Anglo-American method, has not been, in France until now, the object of any complete description. Certain chapters are new: the total suspension of the patient in high fractures of the thigh; the organization of a total service of fractures for their general treatment by suspension, a fortunate simplification. The publishers have placed at the disposal of the authors a rich supply of illustrations. Every apparatus is represented as well as every instance of its application. The preferences of the authors are clearly for the Thomas splint. I can only approve of them. It is, in my opinion, the ideal apparatus because it adapts itself to all conditions of treatment. The book of Desfosses and Robert, coming from their wide experiences with the armies, ought to be a constant guide to all who wish to apply the extension-suspension method."

Although the subject is now rather hackneyed, the book is redeemed by the thoroughness in consideration of details and by the voluminous illustrations, some of which tell more at a glance than can be expressed in a page of description. Because of the many pictures, an abstract falls short in expressing the value of the book.

The suspension treatment seems to have been first used during the Balkan wars. The frame of that name was originally a little different from the form now in use, being low at the foot of the bed and high at the head and having a base for each upright piece to furnish stability. An innovation by Robert reduces the multiplicity of frames in equiping an entire ward for fractures. Instead of an independent frame for each bed, two long beams are put up along the row of beds, one at the heads and one at the feet, supported by a few uprights and coupled to one another by several beams, one or two for each bed, parallel with the beds. Thus we have a sort of compound frame under which is a row of ten to twenty beds. The several overhead beams connecting the two main supporting beams (corresponding to the long overhead bars of the single Balkan frame) are adjustable to any position or angle required by the necessities of the case under treatment.

Chapter II deals with fractures of the arm. The Thomas splint is featured emphatically. A variation which allows this splint to conform to the angle of abduction is the pivoting of the ring with the bars of the splint. This allows a better distribution of the counter pressure around the shoulder and axilla. Extension is obtained by adhesive attached to the forearm and tied to the end of the splint. The arm and splint are suspended by pulley and counter weight. If the reduction is good the arm is kept in this apparatus until union occurs, otherwise the Thomas splint is to be considered as temporary.

Blake's method for fractures of the arm is also described. It consists in extension by weights instead of counter pressure, flexion of the elbow with the forearm suspended vertically by pulley and weight, hammock suspension of the upper arm, and extension by adhesive to the upper arm through a pulley at the side of the bed. No rigid splints are used in this method of Blake's. An apparatus devised by Miss Gassette is also pictured. This defies description in words and appears clumsy and impractical. The traction is pictured as being obtained over a pulley and back to a band around the

patient's pelvis. Counter pressure is not provided for and apparently would have to be supplied by the patient's own muscular effort to keep his trunk from being pulled over toward the side of the fractured arm.

Minor modifications are made in the Thomas or Blake methods to fill the demands of upper, middle and lower third positions of fractures of the humerus, including provision for flexion of the elbow in low fractures. Suspension is also advocated for fractures of the forearm. If the wound precludes the application of adhesive to the arm, a glove is fastened to the hand with Heusner's glue and traction applied to it through strings tied to the end of each finger of the glove, which projects beyond the finger of the hand, to obtain the necessary extension, the arm being swung in a Thomas splint. Two methods, those of Blake and Gassette are described, but the counter extension in both these seems impractical. It is pictured as being obtained by pressure at or above the elbow, which would seem not only to interfere with circulation but to be conducive to ischemic paralysis.

In Chapter III the application of traction-suspension for fractures of the lower limbs is considered. In addition to the classical methods of extension, some inventions arising from the necessities of the war are described. Among these is a foot piece of Sinclair which is fastened by seven independent adhesive strips placed transversely across the sole, the ends not quite meeting on the dorsum of the foot. Through this piece, extension can be obtained in cases of fracture as low as the ankle. An apparatus after Chutro is described for extension in fractures of the femur by means of a flexible steel band passed through the heel in front of the Achilles tendon and above the os calcis. Several other methods for application of extension (eight in all); some of which are classical, are described.

A systematic description of metallic splints for support of leg and thigh fractures is given and includes those of Thomas, Blake, Keller and Lardennois, all of which work by counter pressure on the ischium, and those of Hodgen, Gassette and Leriche, which do not make pressure on the ischium.

Special consideration is given to fractures of the thigh and the methods for keeping the member in the desired position of flexion at knee and hip, abduction and external rotation. The Thomas splint with variations and additions to suit the case seems to be the favorite. The multiplicity of pulleys, ropes and weights as pictured in some cases seems rather complex and one is inclined to wonder whether the system could not be simplified. By the method of Sinclair the leg is secured to the Thomas splint by longitudinal adhesive strips tied to the lower end of the splint. The leg and splint are then suspended by counter weights and pulleys. The primary extension is then the weight of the patient's body and the counter extension is obtained by a rope extending from the lower end of the splint to the transverse bar of the Balkan frame. The authors consider this method "infinitely superior" to traction made directly on the lower part of the leg by weights, because the body weight is much more powerful and accomplishes reductions which can not be obtained by even thirty-five pounds of direct weight. Furthermore, in applying direct weight, so much of the force is absorbed in friction with the splint that only a part is transmitted to the bone fragment. If after forty-eight hours there is still some over-riding in cases treated by the Sinclair method, the foot of the bed is raised higher and one or two pillows are taken out from under the head of the patient. If there is backward displacement, the hammock supporting the thigh is tightened and if the proximal fragment is outside the distal, the abduction of the thigh is increased to bring the distal fragment into line with the proximal.

The methods of Blake and of Keller are briefly described and the classical Hodgen splint considered more in detail. Traction in the Hodgen method is obtained with the knee flexed on the splint, either by means of adhesive or glued straps attached to the thigh only, or by the Steinman nail through the femoral condyles.

An elaborate scheme for total suspension of a patient which seems to have originated with one of the authors is given in detail and illustrated by drawings, diagrams and photographs. A strong hammock passes around the back and a sling under the back of the neck. The pelvis rests in a saddle constructed of padded bent iron rods and the injured leg in a Thomas splint. The sound leg hangs in a sling. All these appliances are hung from the Balkan frames by ropes and pulleys with counter weights all hanging at the foot of the frame. The patient can be easily raised to any desired height out of the bed and remain suspended there by the counter weights, or he can raise himself by means of hand holds hanging down from the frame within convenient reach. This position facilitates the dressing of wounds anywhere on the posterior aspect of the body. Sinclair has devised a hammock of cords on a wooden frame which serves the same purpose as the total suspension apparatus described above for cases of high fractures of the femur.

For fractures of the upper third of the femur, the methods recommended to maintain the position of flexion, abduction and external rotation are those of the Thomas splint, the Hodgen splint and the hammock frame of Sinclair. For the middle third the splints of Thomas and Blake or Hodgen are advised, and for the lower third, either the Thomas or the Hodgen. The method devised by Depage of passing a loop of wire under the lower fragment to hold it up in line in low fractures of the femur, is described.

Fractures below the knee are suspended in a Thomas or Hodgen splint and traction obtained by bands from the leg to the lower end of the splint in the former and by weight in the latter case.

A short chapter is devoted to the suspension treatment of stumps. Bands are glued to the soft part of the stump four in number, upper, inner lower and outer, extending longitudinally and attached to an iron ring about a foot in diameter in a plane at right angles to the axis of the stump, about a foot from the end of the stump. Traction by weight and pulley is then applied to the iron ring thus obtaining equal tension on each band. This prevents the retraction of the soft parts from the bone of the stump.—*William Arthur Clark.*

Society Meeting.

To the Members of the American Orthopedic Association:

In addition to the two days, June 16th and 17th, on which it has been announced that the American Orthopedic Association will meet in Atlantic City with the Congress of American Physicians and Surgeons, there will also be a regular session of the Association on Saturday, June 14th.

On the evening of June 14th the annual dinner of the Association will be held.

Current Orthopaedic Literature

Numerals at head of each abstract are for use in connection with the official "Classification of Orthopædic Literature," published in the JOURNAL for January, 1917, reprints of which are obtainable from the JOURNAL office.

III. ORTHOPEDIC OPERATIVE, POST OPERATIVE, AND ADJUVANT TECHNIC.

III, 1.

SURGICAL TECHNIC IN ORTHOPEDIC SURGERY. By Walter H. Elmer. *Annals of Surgery,* December, 1918.

As all who devote much time to orthopedic surgery know, this branch requires a technic in the operating room which is second to none. Asepsis is of the highest and most vital importance. In his paper Dr. Elmer has gone over some methods for the maintenance of sterilization of the operating field in a very practical manner. His deductions and directions are brief and to the point and are easily understood.

Appended to the article is a set of directions for the preparation of the patient, the operating tables and the instruments. A list of instruments for several operations is attached. Both should be printed, framed, and hung up in the sterilizing rooms of hospitals as a practical help and guide in the anticipation of successful orthopedic surgery.—*Harold A. Pingree, Portland, Maine.*

III, 1.

A NEW PROCEDURE IN AMPUTATION OF THE LEG. Phocas. *Paris Médical,* Nov. 30, 1918, p. 435.

A very simple and reasonable suggestion is made for the facilitation of technic in amputating the leg below the knee,—so simple, in fact, that one wonders why it has not been thought of before. Instead of having an extra assistant hold the leg up in the air and the surgeon almost standing on his head to work on the posterior and most important flap, the patient is placed in the ventral position, thus allowing the leg to lie on the table with the muscular calf containing the vessels and nerves presenting itself where it can be worked upon with ease. Then to bring the anterior side into the field, all that is necessary is to flex the knee on the thigh, in which position the bone is sawed and the anterior flap shaped. The stump can then be laid back on the table and the plastic work done. The only objection which has been made is that of the difficulty and danger in administering the anesthetic in the ventral position. The author meets this objection with his experience that with ether given with the Ombredonne apparatus, the patient's head being turned on the side, the anesthesia is carried on as easily as in the dorsal position.

The author is undoubtedly original in this use of the ventral position, although it has been used from necessity rather than choice in bone graft operations on the spine in which the graft is taken from the tibial crest, the knee being flexed on the thigh for that purpose.—*William Arthur Clark, Chicago.*

III, 1, and III, 7.

IMMEDIATE APPLICATION OF APPARATUS IN CASES OF AMPUTATION OF THE LOWER LIMBS. Roederer. *Le Progrès Médical,* Dec. 7, 1918, p. 409.

The author deplores the fact that insufficient attention is given among French surgeons to the early use of apparatus on leg stumps, a subject which is considered of first importance among the Belgians, English and Americans, and mentions that at one of the nine centers for prosthesis of which he is chief not one amputation case had any provisional apparatus on arrival, in spite of the fact that some of them had been three or four months under treatment. Several good reasons are given for early prosthesis. A stump which is not used undergoes muscular atrophy and becomes fatty. The position which a stump naturally assumes as a result of muscle tension is usually unfavorable for prosthesis, and should be prevented. By early use of the weight-bearing surface the stump will be ready for permanent prosthesis two or three months sooner than otherwise. The patient himself is given early hope and his convalescence is hastened by starting him at once on some sort of an artificial limb. The surgeon who does the amputation should, for his own edification, see an early trial of the stump which he has fashioned and should realize that his work is not ended as soon as the knife is laid away. Immediately prosthesis is part of the therapeusis.

What is said here of the French may be applied also to the Americans, judging from the number of flabby stumps that finally come to the general hospitals. It is within the knowledge of the abstractor that the French were the first to recognize, early in the war, the necessity of early prosthesis with provisional apparatus, and that the Belgians began to take up the work in the early part of 1916.—*William Arthur Clark, Chicago.*

III, 2, *b*.

ORTHOPÆDIC RECONSTRUCTION WORK ON HAND AND FOREARM. A Steindler. *New York Medical Journal,* December 28, 1918.

Steindler's paper embraces a study of sixty cases, and it is impossible to adequately synopsize such an article, but probably the chief point of interest is his dealing with the cases where a transference of the flexor carpi ulnaris and radialis is done for loss of power in the extensor muscles. Before this is undertaken, he thinks there should always be an arthrodesis of the wrist done so it is stabilized in a favorable position, which is that of moderate extension. He then takes the flexor carpi ulnaris and radialis and brings them through the dorsal surface through an opening in the interosseus membrane just above the pronator quadratus. He then fastens them by side to side apposition to the extensor tendons of the fingers, and says that in a very few days after the operation active extension of the fingers can be noticed, but advised keeping the hands completely immobilized four to six weeks and later carefully supported by a splint to be removed only for massage and exercises.

His results following this operation have been satisfactory, and the result in the one case of interosseous tendon transplantation without previous arthrodesis showed only fair correction and function.

In two cases of flexor paralysis of the wrist he swung the extensor carpi ulnaris and extensor pollicis longus around the radius and ulna and fastened them to the flexor digitorum communis. The functional result, however, was only moderate in these cases.

The article is one which does not permit readily of abstracting and should be read by those interested, there being much excellent material in it.—*M. S. Henderson, Rochester, Minn.*

III, 7.

RECONSTRUCTIVE SURGERY. THE PROBLEM OF RECORDS. J. Appleton Nutter, M.D. *The Journal of the American Medical Association,* Feb. 8, 1919.

Dr. Nutter's brief description of the charts used at Hart House, Toronto, for the purpose of recording limits of motion serves to illustrate the fact that pictures, rather than descriptions often best indicate conditions.

Diagrams are used in the records of the Canadian Army Medical Service, and consist of a series of straight lines which represent the bones. These touch at certain points to make the joints and lie at certain angles to represent the extent of motion. The article is illustrated with four line drawings.—*Harold A. Pingree, Portland, Maine.*

XVIII, 8.

NEW OPERATION FOR HALLUX VALGUS. J. Torrance Rugh. *Medical Record.* Nov. 9, 1918.

This condition is divided into two classes of cases—(a) in which the osseous hypertrophy is not excessive, and the angle of deviation of the great toe is not over 30°. Removal of the exostosis is sufficient to cure this class. (b) in which the angle of deviation is more than 30°. The hypertrophy is removed and a cuneiform osteotomy back of the great toe joint is made. In lieu of this procedure the author makes a curved longitudinal incision with the base down over the joint. This flap is turned down. Then he makes a tongue shaped flap with the base backward similar to the Mayo flap. This includes the bursa and the internal portion of the capsular ligament. Sufficient of the epiphysis of the metatarsal bone is removed by diagonal cuts from within outward and from behind forward. The inner sharpened corner is removed, and the second flap is secured across the ends of the bones. Ankylosis is prevented and the deformity is corrected. Excellent results have been attained in twelve cases. The article is illustrated with drawings.—*Edward Z. Holt, Atlantic City.*

XIX. TRAUMATIC CONDITIONS.

XIX, 1.

INVESTIGATION OF 1000 CONSECUTIVE CASES OF PERIPHERAL NERVE INJURIES. J. L. Burrow and H. S. Carter. *British Medical Journal.* November 16, 1918.

This remarkable number of cases was carefully observed and systematically charted. Accurate notes were taken in regard to condition of the skin, joints and muscles of the limb involved, as well as to the local condition of the nerve and paralyzed muscles. Sensory examinations were taken in regard to touch, thermal sensibility, deep sensibility, discriminating sensibility and the electrical reaction was also ascertained, interrupted as well as constant current.

Musculo-spiral nerve found injured in 204 cases, median nerve injured in 242 cases, ulnar nerve injured in 327 cases, sciatic nerve injured in 121 cases.

In connection the author points out the following facts: Trophic and vaso-motor functions are the first to recover. The next to recover are the deep sensory functions, first in regard to pressure and sense of motion in

the joint, and last the discriminating sensation. Voluntary movement appears in highest centers of the muscles and gradually extends downward.

The first change after nerve suture is brisk response to anodal closing stimulus. The faradic responses are usually much slower in re-appearing. Occasionally faradic responses return soon after voluntary movement.—*A. Steindler, Iowa City, Ia.*

XIX, 1.

ON INJURIES OF THE CERVICAL SPINE. Joseph Ransohoff. *Surg., Gynec. and Obstet.* September, 1918.

The author "talks" about 14 cases of cervical spine injury, with six deaths. In a very "readable" article, he takes up the case histories, neurological and x-ray findings and the treatment of the above cases. The results obtained seem to show that his conservative plan of treatment was well founded. It is well illustrated, but does not lend itself to abstracting.—*Leo C. Donnelly Detroit.*

XIX, 1.

MECHANICAL TREATMENT OF PERIPHERAL NERVE INJURIES. By Byron Stookey. *Surg., Genec. and Obstet.* Nov. 1918.

The first cardinal principal of mechanical treatment of peripheral nerve injuries is to obtain relaxation and prevent over stretching of the paralyzed muscles. There are two main types of apparatus: those which aim to prevent over stretching and correct faulty position, and those which attempt to replace a part of the movement lost. An appliance is to be preferred which attempts to correct the total deformity and to prevent over stretching. Each appliance is made for individual cases, modifications when expedient, altered and changed according to progress. Apparatus should be light, simple, easily applied and removed, immobilized no more than is necessary, should be cheap and inconspicuous. Should treat the total deformity, not merely one of the apparent faulty postures. The straps should fall on tendons rather than constrict muscle bellies. Avoid producing pressure sores. Splints removed at night should be replaced by more comfortable and equally efficient retentive apparatus.

Early mechanical treatment. The severed nerve tends to assume a definite position and to keep it, being held more or less firmly in place by the fascial layers which so intimately surround the nerve trunk. The position to be maintained will depend upon the level of the lesion in the nerve. In injuries to the median and musculo-spiral in the upper arm, the arm should be adducted and the forearm acutely flexed; in injuries of the ulnar, the arm is adducted and the forearm held extended; in injuries below the elbow to the median, the forearm is flexed at a right angle and hand placed in full supination, and the same position for the musculo-spiral, except that the hand is held dorsi-flexed; in ulnar injuries at the same level the forearm is fully extended and the hand flexed in slight adduction. The sciatic is relaxed by knee flexion. Where there are other injuries such as fracture, which might lead to more or less permanent deformities, the primary indication is to treat the fracture.

Correction of deformity before operation: Prior to operative interference in nerve injuries all contractures must be overcome and free mobility of joints assured. Contractures and adhesions should be stretched gradually and continuously, as daily movements when of sufficient force to increase mobility constantly tear the fibrous tissue, which in turn sets up new

fibroblastic reaction. Gradual overstretching gives less reaction and is more permanent.

In brachial plexus injuries to the 5th and 6th cervical nerves the arm must be abducted to relax the deltoid and supraspinatus; and in external rotation. Abducted to 60 degrees and held in the mid coronal plane, the arm overcorrected in external rotation and the forearm flexed on the arm, and held in slight supination so that the hand faces the mouth. A splint is described to maintain this position.

In injuries involving the last cervical and first dorsal nerves a straight splint in line with the forearm, with individual grooves for each finger, with the fingers in slight abduction, offers the most satisfactory mechanical treatment. In seventh cervical and musculo-spiral paralysis mechanical treatment aims to relax the deltoid and overcome the results of gravity on the extensors. In musculocutaneous paralysis there is very little mechanically indicated; holding the forearm flexed and the hand supinated prevents over-stretching, which also is guarded against by the engagement of the olecranon against the humerus. Ulnar nerve. The clinical manifestations are extremely variable, due to the large number of muscles supplied, and their rather antagonistic action, and to the variability of supply. Efficient immobilization must be combined with efficient mobilization. All movements should be regularly performed and the periods of repose guarded by suitable apparatus. For a complete lesion a simple palmar splint with individual gutters for each finger will usually suffice. In median nerve paralysis a straight splint with slight flexion for the distal phalanx, with separate grooves for each finger will suffice. In anterior crural paralysis a Thomas walking caliper splint is applied allowing of 30 degrees flexion and prohibiting hyperextension. In total sciatic paralysis there is complete flaccidity below the knee, for which a modified Thomas splint is applied, permitting knee flexion to 45 degrees, fixed to a sole plate maintaining foot in dorsal flexion. Inner side of heel and sole is raised to prevent valgus deformity.

In paralysis of the external popliteal the deformity to be prevented is one of pes equino varus. An inside iron attached to the shoe preventing plantar flexion, combined with raising of outer portion of heel and sole, correct the deformity. Internal popliteal paralysis generally produces pes calcaneo valgus. An outside iron with stop lock prevents dorsal flexion. An arch support holds up the arch. Raising the inner side of heel and sole aids in preventing valgus. For flat foot following paralysis a properly made steel arch is supplied.

Electricity, massage, and baths are taken up in their application to nerve injuries. This article is long, well illustrated, and goes into details of diagnosis and in a way is a résumé of experimental nerve surgery done at the University of Michigan. It should be studied, not read.—*Leo C. Donnelly, Detroit.*

XIX, 2, *a*.

FRACTURE OF THE NECK OF THE FEMUR. James Warren Sever. *Boston Med. and Surg. Jour.*, Jan. 9, 1919.

This is a careful report of the end results of 40 cases of fracture of the neck of the femur in men and women of all ages. There are 21 cases of the intertrochanteric type and the others represent the sub-capital type of fracture. The good results represent only 23% of the cases with known results.

The author advocates the Whitman method of treatment by means of

forced abduction, and questions the necessity or advisability of the forcible impaction method as used by Cotton.

The paper is illustrated with numerous line drawings and will well repay the study of those who are called upon to treat this type of case.

XIX, 2, *a*.

THE ABDUCTION TREATMENT OF FRACTURE OF THE NECK OF THE FEMUR. A Comparative analysis from the standpoint of technical efficiency. Royal Whitman. *Surg., Gynec., and Obstet.*, Dec. 1918.

In an article well illustrated the author advances his method of treating fractures of the neck of the femur. The anesthetised patient, clothed in fitted shirting or a combination suit, is lifted to a pelvic rest screwed to the end of the table and provided with a perineal bar for counter traction, the shoulders resting on a box of equal height. The limbs extended, and side by side are each supported by an assistant. Direct manual traction is then made by the assistants against the resistance of the perineal bar, while the surgeon, standing on the injured side, lifts the thigh upward, guiding the trochanter to its normal position. When the shortening has been reduced as demonstrated by comparative measurements, the limb, which is usually rotated outward, is turned until the patella turns slightly inward. The two assistants, still exerting equal traction on the limbs, abduct them, that on the sound side slightly in advance, in order to demonstrate the normal range and to benefit its fellow, so that the tension on the capsule as the fracture is adjusted may not tilt the pelvis upward. A final inspection shows the extended limbs equally abducted on a level pelvis with all the landmarks corresponding, complete abduction, complete extension, slight internal rotation. Plaster cast extends from nipples to the toes of the injured limb; on well side so cut as to allow complete flexion. The support assures anatomical rather than direct splinting. The long spica is most effective because the leverage above and below the joint is about equal. The limb is hyperextended in order that the strong anterior wall of the capsule may be made tense and because support in this position checks any tendency toward backward displacement of the outer fragment to which the force of gravity predisposes. Slight flexion of the knee lessens the strain on the joint, and inward rotation follows the principle of over correction of preëxisting deformity. The head of the bed is raised a foot or more by blocks, the patient turned at intervals to avoid hypostatic congestion.

The plaster spica is retained as a support from eight to twelve weeks to assure adhesion of the fragments, but by no means a resistant union. After its removal the patient remains in bed for several weeks for massage, passive and active movements of the joints and reëstablishment of the muscular control. Several times a day the limb is drawn out by the attendant to the full limit of abduction, otherwise a gradual restriction of its range will be apparent. Weight bearing should never be permitted, with the possible exception of certain fractures at the base of the neck, or in childhood, for at least six months, and often only after a much longer interval, because the repair is slow and the strain is great. The indications for the resumption of functional use are the situation of the fracture, the process of repair as shown by the x-ray, by the restoration of voluntary control and the freedom from discomfort on passive movements. The use of a caliper hip splint which permits of locomotion without direct weight bearing is desirable; otherwise crutches are necessary.—*Leo C. Donnelly, Detroit.*